subject is best discussed by first supposing that the materials are incompressible, and tracing the conditions of stability on this hypothesis, and then by examining in what respect those conditions are modified by the limited strength of the materials.

Art. 6.—In applying the following methods to analyse the strength of any given structure, the first question to be solved is: Is the structure, when acted on by the given pressure, on the balance between standing and falling? The problems determine if this is the case, and if not, if the tendency is towards stability or instability. If the structure be on the balance between standing and falling, then the slightest alteration in the pressures may cause it to fail, and it would therefore be condemned as unsafe. If the tendency be towards instability, unquestionably the arch will not stand. If, on the other hand, the tendency be towards stability, then another question arises: How great a degree of strength does the structure possess? When it is decided in what terms this strength is to be measured, the problems in the following pages can be applied to answer the question. Thus, the strength may be measured by the weight in different positions and directions, that will be required to produce the state of unstable equilibrum, or the balance between standing and falling. Or, again, the strength of the material may be hypothetically diminished, until this unstable equilibrum is produced, and thus a measure of strength is obtained; as for instance, if the hypothetically diminished strength of the material is one-tenth the actual strength of the material used, then the structure is ten times stronger than is theoretically necessary.

Section II.

Art. 7.—On the conditions of stability of an arch whose voussoirs are incompressible; the form of which, and the pressures sustained by it, as regards position, direction, and amount, being similar on either side of the crown of the arch.

In such an arch, the conditions of failure are, as before stated, the first and second; that is, the voussoirs may slip on one another, or turn over on their edges: the latter condition will first be discussed.

It need not be proved, that if in one part of an arch the voussoirs turn over on their edges at the extrados, causing the joint to open at the intrados, then at some other positions, other voussoirs must turn over on their edges at the intrados and the joints open at the extrados. Also it need hardly be proved, that if the arch is similar in form and similarly loaded on either side of the crown, that if failure takes place, in the manner above described, one of the points of rupture will be at the crown of the arch: this is nearly self-evident, and may be proved by experiments on any model of an arch; it is, however, proved geometrically by application of the problem in Section 4. If the arch fails at the crown, by the voussoirs turning on their edges A_1, at the extrados, as in diagram 7, then at some point in the haunches, the voussoirs will at the same time be turning on their edges A_2, at the intrados, in which case the crown will sink and the haunches will spread.

If the arch fails at the crown, by the voussoirs turning on their edges at the intrados, as in diagram 8, then at some point in the haunches, the voussoirs will, at the same time, be turning on their edges A_2, at the extrados, in which case the haunches will sink and the crown of the arch will rise.

Art. 8.—When the arch is failing, as shown in diagrams 7 and 8, then the points of application of the resultant pressures at the places of failure are beyond the edge of the voussoir, as shown in diagram 3. But when the arch is in the condition of unstable equilibrium, that is, when it is on the balance between standing and falling, and when the voussoirs are on the point of turning on their edges at A_1, A_2, &c., then the point of application of the resultant pressure must be at the extreme edge of the voussoir, and its direction must also be that of the tangent to the intrados, or extrados, at A_1, A_2, &c., because if not, the line of resistance passes without the boundary of the voussoirs, either on one or other side of the point A, and the structure has already failed, by the turning over of some other voussoir. Therefore, when the arch is in the condition of unstable equilibrium, then, at all the points of rupture, the directions of the resultant pressures are tangents to the intrados, or extrados.

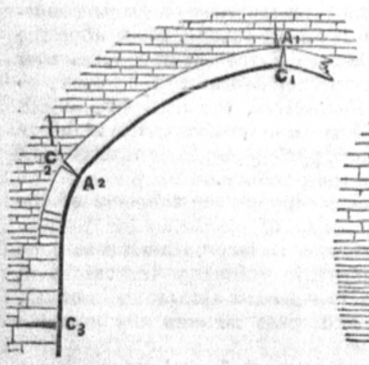


Diagram 7.

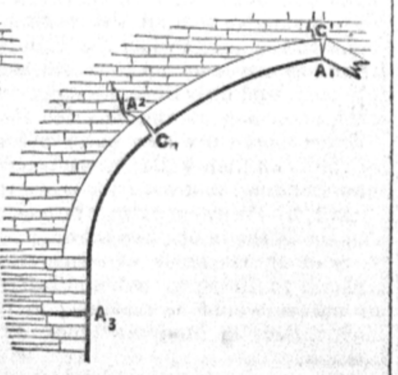


Diagram 8.

Art. 9. *Problem* 2.—To find the second point of rupture, in an arch whose voussoirs are incompressible, the form of which and the pressure sustained by it, as regards position, direction, and amount, being similar on either side of the crown of the arch.

Also to find the amount of pressure at the crown and at the second point of rupture.

Take for example an arch with a backing, or superstructure, diagram 9. It is required to find the second point of rupture, that is, that point in the haunches, at which the voussoirs will be about to turn on their edges, when the arch is in the condition of unstable equilibrium.

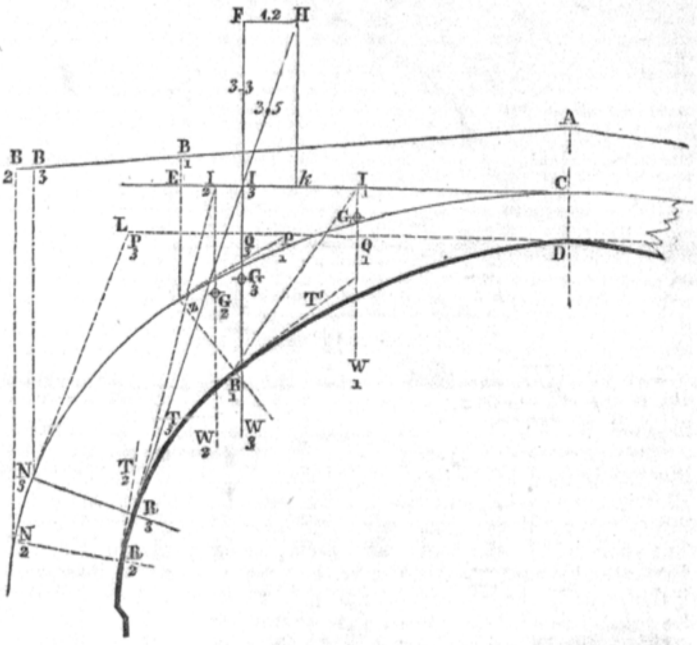


Diagram 9.

As the form of the structure leads to the supposition, that, if failure take place, it will be by the sinking of the crown and the spreading of the haunches, let it be first assumed that the arch is about to fail in that manner. Then the point C, in the extrados, at the crown, will be the first point at which the voussoirs are about to turn; and the horizontal line C E, will represent the direction and position of the pressure upon the side of the arch drawn in the figure, caused by the weight of the opposite and similar side: see Art. 8.

Choose some point R_1, in the intrados, and, for trial, suppose that to be the second point of rupture. Then the voussoirs will be on the point of turning on their edges at R_1, and the resultant pressure will act through R_1, in the direction R_1 T_1, of the tangent to the intrados: see Art. 8. Draw the joint or normal to the intrados R_1 N_1, and the vertical line N_1 B_1. Find the centre of gravity of the mass A D R_1 N_1 B_1; and draw the vertical line G_1 W_1, and produce it till it intersects C E, at the point I_1. Then the only pressures acting on the point R_1, are the pressure of the opposite arch, acting in the direction C E, and the weight of the mass A D R_1 N_1 B_1, acting in the direction I_1 W_1; and since the direction of these two pressures intersect in the point I_1, therefore, by the well-known law of Statics, the direction of their resultant also passes through the point I_1; but when the arch is about to fail at the point R_1, R_1 T_1 is the direction of the resultant, and this does not, if continued, pass through the point I_1. Therefore, R_1 is not the second point of rupture, and some other point must be tried. If the line R_1 I_1 be drawn, it will be seen that its direction is less inclined to the vertical than R_1 T_1; and this leads to the supposition that the point of rupture is lower down, at some point where the tangent to the curve is less inclined to the vertical. Therefore, choose some other point R_2, and pursue a precisely similar method to that described for R_1, as shown in the figure.

Then, since the tangent R_2 T_2, produced, does not pass through the point of intersection I^2, but is less inclined to the vertical than the line R_2 I_2, the point of rupture is above R_2. Also since the line R_2 T_2, more nearly coincides with the line R_2 I_2, than the line R_1 T_1, with the line R_1 I_1, the point of rupture is nearer to R_2, than to R_1.

One more subsequent trial generally suffices to determine the correct point, which, in this example, is the point R_3. For the tangent R_3 T_3, produced, passes through the point I_3, which is the point of intersection of the direction of the weight of the mass A D R_3 N_3 B_3, and the pressure of the opposite of the arch. Therefore, if the arch fails by the sinking of the crown, the second point of rupture is R_3.

The second case is now to be considered: Where will be the second point of the rupture, if the arch fails by the rising of the crown? Draw the horizontal line D L, which will, in this case, represent the position and direction of the pressure of the opposite side of the arch. Let the point N_1 be tried; then if N_1 be the point of rupture, the tangent to the extrados at N_1 N_1 P_1, will, if produced, pass through the point Q_1, which is the point of intersection of the directions of the pressures of the opposite side of the arch, represented by the line D L, and of the weight of the mass A D R_1 N_1 B_1, represented by the vertical line W_1 I_1. But N_1 P_1 intersects the line D L, far from the point Q_1. Also if the point N_3 be tried, it will be found that the tangent N_3 P_3 is far distant from the point of intersection Q_3; and in like manner it will be found, that at no other point above N_3, will these conditions be fulfilled, except at the point C. Therefore the arch will not fail by the rising of the crown. Therefore the arch will, if it fails, fail by the sinking of the crown and the spreading of the haunches; and the point R_3 is the second point of rupture.

Art. 10. *The second part of the Problem.*—It is required to determine the amount of pressure at the crown, and at the second point of rupture.

Construct a scale of equal parts, as in Problem I, each division representing some unit of pressure, as pounds, hundred-weights, or tons. Through the point of their intersection I_3, produce the lines R_3 I_3, and W_3 I_3; then on the line W_3 I_3, produced, measure off the distance, I_3 F, containing as many equal parts of the scale as these units of weight, in the mass A D R_3 N_3 B_3, and from the point F, draw a line parallel to C E, intersecting the line R_3 I_3, produced at the point H. Then, by the well-known principle of the parallelogram of pressures, the line F H contains as many equal parts of the scale as there are units in the pressure of the opposite side of the arch on the crown at C, and the diagonal of the parallelogram H I_3, contains as many equal parts as there are units in the pressure on the point R_3. Thus, in Exampe 1, if the weight of the mass A D R_3 N_3 B_3, is 3 tons 3 cwt., then the pressure at the crown will be 1 ton 2 cwt., and the pressure at the point R_3, 3 tons 5 cwt.

Art. 11.—Thus the resultant pressure on one of the blocks of the structure is determined in direction, position, and amount, which is the datum required in Problem 1; and therefore, that problem may be applied and the line of resistance be traced, as in the example in Art. 3, through the whole structure, commencing either from the crown, or from the second point of rupture; and this line will represent the resultant pressures at every part of the structure, when it is on the balance between standing and falling, that is, when it is in the condition of unstable equilibrium.

If the line of resistance, at any point, passes without the boundary of the voussoirs, the structure will unquestionably fail. If it touches the extrados, or intrados, at other points, and at the base, then the structure is in the condition of unstable equilibrium. If the line of resistance passes through the base of the structure, some distance within the mass, then the arch has a certain degree of stability, which may be tested, as described in Art. 6, by the methods given in the following Sections.

The stability of the structure, with regard to the first condition of failure (Art. 1, diagram 2), has to be considered, and is at once determined by inspecting the line of resistance, drawn as described in the foregoing examples. If at any part of the structure a joint is made, in such a direction, that a perpendicular drawn from it shall be inclined from the tangent to the line of resistance, at that point, at an angle greater than the limiting angle of resistance of the surfaces of contact, the structure will fail at that place; if, however, this is not the case at any position in the arch or pier, then the structure will not fail by the slipping of the blocks one upon the surface of the other, and the first condition of failure will not be fulfilled.

SECTION III.

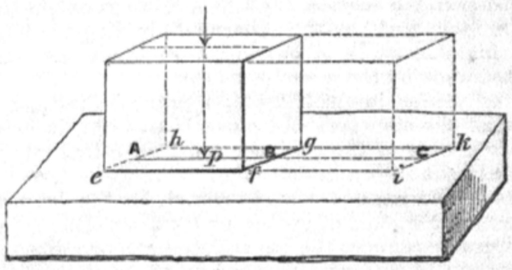
On the conditions of stability of an arch, the form of which, and the pressures sustained by it, as regards position, direction, and amount, are similar, on either side of the crown of the arch; the limited strength of the materials being taken into consideration.

Art. 12.—By reference to Art. 6 it will be seen, that it is there proposed, that the conditions of stability in an arch should first be discussed on the supposition that the materials were incompressible, and that then it should be examined in what respect those conditions were modified by the limited strength of the materials used in building. The first part of this proposition has been considered in Section II. It is the purpose of this section to consider the second part.

The arches in the examples in the last section could not stand if they were built of any material at present known, because at the points of rupture, the resultant pressures act at the extreme edge of the voussoirs, and therefore all the pressure has to be resisted by these extreme edges, or by a single line, which cannot be the case, unless the material is incompressible. So that in all practical cases of arches, even the condition of unstable equilibrium cannot be attained, unless the position of the line of resistance is some distance within the section of the arch. The question which then arises is, how near to the intrados or extrados can the line of resistance pass, without causing the failure of the materials?

Art. 13.—Experiments to determine the strength of stones to resist compression, have for the most part been made by the application of pressures on cubes of the stone, in a direction perpendicular to the face of the cube, as in diagram 10. The resultant of this pressure, and the weight of the stone, acts in the direction of the axis of the cube, its point of application being in the centre of the base at p; so that if any line be drawn through this point p, to the edges of the block, as the line A B, the portion p A is equal to the portion p B: and as, by the principle of the equality of moments, the pressure on the point A, multiplied by the length A p, is equal to the pressure on the point B, multiplied by the length B p; since the length A p, is equal to the length B p, the pressure on the point A, is equal the pressure on the point B; and similarly the pressure on the whole edge of the stone e h, is equal to the pressure on the opposite edge f g.

Diagram 10.



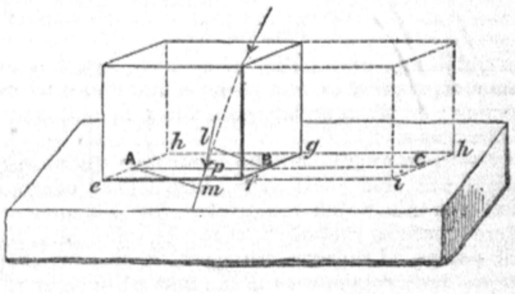


Diagram 11.

Now let the block of stone, as shown in diagram 11, be acted upon by a pressure whose direction is inclined to the axis of the block, but which is applied in such a position, that the resultant of it, and the weight of the block, acts through the point p, in the centre of the base. Draw any line A B, through the point p, to the edges e h, and f g, and draw another line through p, in the direction of the resultant, and from the points A and B, draw lines A m, B l, perpendicular to this line. Then, by the principle of the equality of moments, the pressure on A, multiplied by the length A m, is equal to the pressure on B, multiplied by the length B l. But since p B, is equal to p A, the angle A p m, is equal to he angle B *p l*, and the angles A *m p*, B *l p*, are right angles; therefore, the length B *l*, is equal to the length A *m*, and therefore, the pressure at A, is equal to the pressure at B, and similarly the pressure on the whole edge *e h*, is equal to the pressure on the whole edge *f g*. Therefore, in both cases, diagrams 10 and 11, the the pressure will be sustained in a similar manner, by the base *e f g h*. So that if the resultant pressure at *p*, diagram 10, is equal to one ton per square inch of the surface *e f g h*, and does not crush the particles in that surface, then, if the resultant at *p*, diagram 11, is equal to one ton per square inch of the surface *e f g h*, the particles in that surface will not be crushed.

If in either of the cases, Diagrams 10 and 11, the portion *f i k g*, be added, it is evident that the pressure on the base *e f g h*, will not be increased. And therefore, if a stone, as in diagram 12, be acted on by a pressure, the resultant of which, and the weight of the stone, passes through a point *p*, in the base *e i k h*: Draw a line A C, through the point *p*, to the edges *e h*, and *i k*; then measure off, on the line *p* C, a portion *p* B, equal to the length *p* A, and draw the line *f* B *g*, perpendicular to the line A C. Then, if the resultant pressure at the point *p*, divided by the number of square inches in the surface *e f g h*, is not greater than the pressure per square inch, that (by the experiment in diagram 10) the material was found capable of bearing, then the stone will not fail when acted upon by the given pressure.

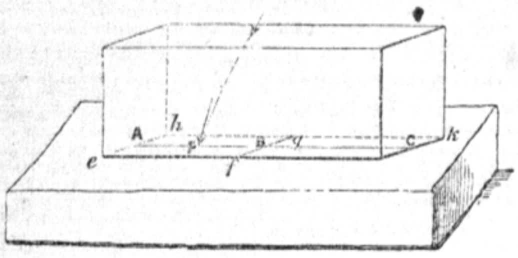


Diagram 12.

It is of course implied, that no natural fault, or laminated structure, of the stone, should cause it to yield, it being evident that the judgment of the engineer must be called into requsition, to guard against such a catastrophe.

Art. 14.—The method here proposed, for the determination of the proper section, &c., of arches, or for discussing the stability of arches already designed, the limited strength of the material being taken into consideration, is founded on the above-mentioned principle.

Section IV.

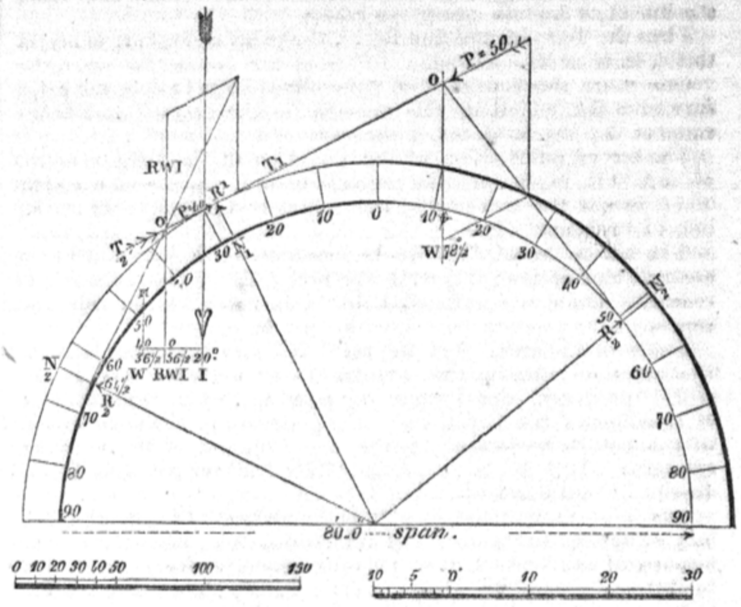
On the conditions of stability of an arch, acted upon by forces of any amount, applied in any position and direction in the plane of the section; or of an arch, whose form is not similar on both sides of the crown.

Art. 15.—In an arch under the conditions stated at the head of this section, the first point of rupture is not necessarily at the crown, and it is this which constitutes the difficulty of the question. It may here be remarked, that when the terms first, second, and third points of rupture are used, it is not meant that the failure of an arch commences at the first point, and then spreads to the second point of rupture, and so on; for theoretically speaking, the structure will fail at all those points at the same time; but by the first point of rupture is merely meant the point of rupture first determined, and by the second point of rupture, the point of rupture secondly determined, as by the process detailed in the preceding sections, one point of rupture being already known.

Art. 16. *Problem* 3.—To find the first point of rupture in an arch acted upon by any given pressures, in any given position, and the arch itself being of any given shape. The method proposed to solve this problem will, it is thought, be more easily shown, by reference to the example of the arched vault in the previous sections, than by a general diagram and demonstration.

Example.—Let the arched vault shown in diagram 13, of 80 feet span, and whose depth of voussoir at the crown is equal to one-ninth of the radius, be acted on by a pressure, equal to the weight of a portion of the arch of 20° length of intrados, and one foot in length of transverse section, and applied vertically to the extrados, at a distance of 30° from the crown. Required the first point of rupture, under these conditions; the materials being incompressible. First, suppose for trial, some point R_1 in the extrados, to be the first point of rupture, say 28° from the crown, as in diagram 13. Draw a tangent T_2 R_1 T_1, to the extrados at R_1. Then if R_1, be the first point of rupture, R_1 T_1, and R_1 T_2, represent the direction of the pressure of one portion of the arch on the other, when the arch is about to fail at that point; for then the line of resistance touches the extrados at R_1. Also R_1 being the first point of rupture, and the arch being about to fail, the pressure of the lower portion of the arch, in the direction T_2 R^1, must be equal to the pressure of the upper portion, in the direction T_1 R_1; for the pressures must be in equilibrium about the point R_1, and if one is preponderating, then the arch has already failed somewhere else, and the voussoirs, if about to turn on their edges at the point R_1, are moving in the direction of the preponderating pressure. On the supposition that R_1 is the first point of rupture, find the second points of rupture, R_2, on the right and left hand sides of the arch, in the same manner as described in Section II. Problem 2.

Diagram 13.



In this case, the second point of rupture on the right hand side, is at the intrados, at 51° degrees from the crown; for the vertical line, drawn through the centre of gravity of the mass R_1 N_1 R_2 N_2, intersects the tangent to the extrados, at the crown R_1 T_1, at the point O, and the tangent to the intrados at R_2, also passes through the same point. Also the second point of rupture, on the left hand side, is at the intrados, 64° distant from the crown; for the direction of the resultant of the weight of the mass R_1 N_1 R_2 N_2, and the force impressed on the arch, intersects the tangent to the extrados at R_1, and the tangent to the intrados at R_2, at the same point O.

Next, construct the parallelograms of pressure, as shown in diagram 13; in that for the left side, the vertical line marked R W I, represents the resultant of the weight of the mass, 36°, and the impressed forces equal to the weight of 20° of the arch; and these being pressures in the same direction, this resultant equals the weight of 56° of the arch, and the side of the parallelogram R W I, is equal to 56 parts of the scale. The directions of the other two pressures are sufficient to determine the parallelogram, by which it appears, that the pressure of the lower portion of the arch on the point R_1, in the direction T_2 R_1, is equal to the weight of 40° of the arch.

In the same manner it will be found that the pressure of the upper portion of the arch on the point R_1, in the direction T_1 R_1, is equal to the weight of 50° of the arch. But the pressure in the direction T_2 R_2 is equal to the weight of 40° of the arch, therefore the pressure at the point R_1, of the upper portion of the arch, upon the lower, is greater than that of the lower portion and its impressed force, on the upper. Therefore R_1 is not the first point of rupture.

Take therefore, for trial, some other point nearer the crown of the arch, for the point of rupture; for it is evident, that as the point of rupture approaches towards the crown, the pressure on it from the left side, will be greater; and that from the right side be less. Let this second trial point be 15° from the crown; repeat with regard to this point, a process similar to that above described, and as shown in the diagram; and it will be found, that the pressure from left to right is equal to the weight of 42½° of the arch, and that from right to left, equal to the weight of 44°; so that the pressures are very nearly in equilibrium; therefore, the first point of rupture is very near this trial point; and the pressure of the right side of the arch preponderates: therefore, take for the next trial, a point a few degrees nearer the crown.

Thus the first point of rupture will soon be arrived at, which, in this case, is at the extrados, 10° from the crown, for when the voussoirs are about to turn on their edges, at this point, the pressure from the left equals the pressure from the right; each being equal to the weight of 41° of the arch.

The second point of rupture on the right side, is at the intrados, 55° from the crown, and the pressure there is equal to the weight of 71° of the arch; then Problem 1 can be applied, to trace the line of resistance through the rest of this side of the structure, and it will be found, that for the arch to be in the condition of unstable equilibrium, about the springing, it is necessary that the voussoirs should be deepened about 12 inches, at 86° 40′ from the crown.

The second point of rupture on the left side, is at the intrados 62° from the crown, and the pressure there is equal to the weight of 90° of the arch, and Problem 1 being applied to trace the line of resistance through the rest of the structure, it will be found, that for it to be in the condition of unstable equilibrium, at the springing, the voussoir must be notched at the extrados, to the depth of about 6 inches.

Art. 17.—The principles and the method described in Section III. may be applied to the arch sustaining pressures, as described in the heading of this section, and of unsymmetricical form; as well as to that arch whose pressures and form are similar on both sides of the crown, as described in Section II.

It is also evident, that the above method will apply to any irregular form of arch, and that the principles and method described in Section III. might also be applied.

ON A GENERAL THEOREM TO CALCULATE THE AREA OF A CROSS-SECTION OF A RAILWAY ON SIDELONG GROUND.

By R. G. Clark.

The intention of this paper is to investigate a formula, free from surds or any approximation, to compute the area of a cross-section, without having regard to the side stakes. We have given (fig. 1)

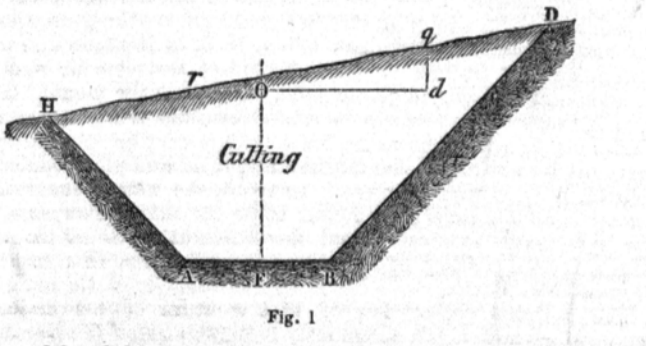


Fig. 1

the breadth of formation level A B; the depth O F from centre stake; the difference of heights $q\,d$, taken by the spirit-level; the corresponding hypothenusal length $q\,r$; and the ratio of the slopes. On referring to page 68, present volume, article "Railway Sections in Sidelong Ground," to formula (3), which is

$$(2\,b+m\,a)\,a+\tfrac{1}{2}\,(b+m\,a)\,(x-x')\sin\theta=\text{area};$$

where $b=\frac{1}{2}$ formation level; $a=$ depth or height from centre stake to centre of formation level; x and x' equal the distances O D, O H; $\theta=$ angle of inclination of ground; and m base of slope to one perpendicular. Also let $h=$ difference of heights by level $r\,d$; and $l=$ O d, the hypothenusal length on surface.

From (1) and (2), page 67, in the article above referred to, put

$$\text{T}=\frac{1}{\cos\theta-m\sin\theta},\text{ and T}'=\frac{1}{\cos\theta+m\sin\theta};$$

then the above formula becomes, by substituting T and T′,

$$(2\,b+m\,a)\,a+(b+m\,a)^2\,(\text{T}-\text{T}')\times\frac{\sin\theta}{2}=\text{area}\ \ldots\ldots\ (4)$$

But $(\text{T}-\text{T}')\times\frac{\sin\theta}{2}=\frac{2\,m\sin\theta}{\cos^2\theta-m^2\sin^2\theta}\times\frac{\sin\theta}{2}=$

$$\frac{m^2\sin^2\theta}{\cos^2-m^2\sin^2\theta}=\frac{m\tan^2\theta}{1-m^2\tan\theta^2}.$$

Now consider, in the right-angle triangle $q\,d\,r$, the height $q\,d=h$ to be a tangent, the horizontal distance $d\,r$ the radius; therefore, $\tan^2\theta=\frac{h^2}{l^2-h^2}$. Substitute this value in last expression, and then in (4); we have for the required general formula:

$$(2\,b+m\,a)\,a+(b+m\,a)^2\,\frac{m\,h^2}{l^2-h^2-m^2\,h^2}=\text{area H A B D}\ (5)$$

Let the slope be 1 to 1; then $m=1$; ∴

$$(2\,b+a)\,a+\frac{(b+a)^2\,h^2}{l^2-2\,h^2}=\text{area}\ \ldots\ldots\ldots\ldots\ (a)$$

The general formula is more simple than it appears: when these numbers are large, we shall only require a table of square numbers to work out any question. Two examples are subjoined:—

1. Given length on slope of ground = 20 feet; the difference of heights, 6 feet; slope to be 2 to 1; depth of cutting, 20 feet; and breadth of formation level, 30 feet. Find area by the formula (5).

Substitute the above values in (5):

$$(33+40)\,20+(16{\cdot}5+40)^2\,\frac{2\times36}{400-180}=2504{\cdot}7,\text{ area required.}$$

2. Given the length 20 feet on descent of ground; difference of heights by level, 6 feet; intended slopes, 1 to 1; depth of cutting, 45 feet; and breadth of formation level, 33 feet. Find the area. (*See* fig. 1; and for embankment, *see* fig. 2.)

By substituting the above values in (a):

$$(33+45)\,45+\frac{(16{\cdot}5+45{\cdot})^2\,36}{400-72}=3925,\text{ area required.}$$

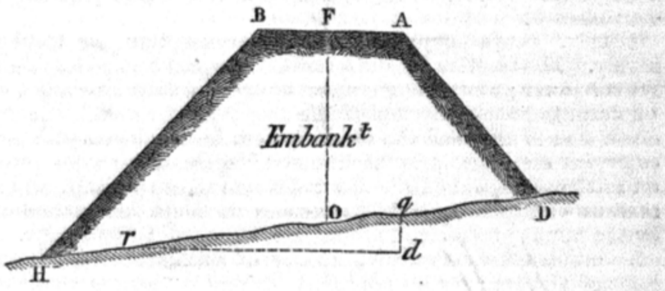


Fig. 2.

From the above it may be observed, that when a centre line of railway is ranged and staked out, and the depths known on inclined ground, we can always find most expeditiously the area of any vertical cross-section, by means of the spirit-level, without requiring the distances of the side stakes from the centre. By way of comparison, I have to refer to an article for a similar purpose, page 263, vol. VII. of this *Journal.*

SOCIETY FOR THE PUBLICATION OF ARCHITECTURAL KNOWLEDGE.

From what has been said of it, the main purpose of this Society—which, perhaps, may not mean to call itself exactly by the title for the present assigned to it—seems to be to bring out what shall be a complete Dictionary or Encyclopædia of Architecture—a very meritorious undertaking, and one which, as the want of such a work is felt, might have reasonably enough been expected on the part of the Institute. That the present Dictionaries which we have of the kind are all more or less defective and unsatisfactory, even considered with reference to the time when they were produced, is universally admitted. Even had they no other deficiencies, they have one and all lagged very much behind the actual time when they made their appearance, whereas every work of the kind ought to bring down its information to the latest possible moment. Let us hope this important point will be attended to in the one now promised, and that it will duly notice all those improvements, both in matters of construction and those of embellishment, which have come up of late years, and to which every year adds something. As the Society in question of course looks to usefulness and reputation, rather than to anything in the shape of pecuniary profit, we may fairly anticipate from it something greatly superior to everything else of the kind. Much will depend upon their most carefully maturing the whole of their plan beforehand,—a work of no small labour in itself, but which would save them innumerable difficulties and perplexities. Let nothing be overlooked: let them not have to say, when midway in their task, we did not think of this, or of that, and it is too late to think of it now. Beyond this we cannot attempt to give any sort of special advice, because if anticipated by themselves it might be construed into downright impertinence. We can only say that we shall gladly open our columns to any more correct and fuller information as to its objects which the Society may deem proper to communicate.

REVIEWS.

GEOMETRY FOR THE MILLION.

Principles of Geometry, Mensuration, Trigonometry, Land Surveying, and Levelling. By THOMAS TATE. London: Longman and Co., 1848.

We have read this work with sincere regret: for in every point of view it is calculated to be injurious. It will be injurious to those who take it as a guide for the study of geometry; and it will materially injure the character which Mr. Tate had fairly established by his previous writings, both as a mathematician and an instructor. We could, indeed, scarcely believe, whilst turning over the pages, that we had not taken up the wrong work; and we once actually (under the impression that it could not have been written by Mr. Tate) turned back to the title-page to verify our unbelief!

Of Mr. Tate's other works, without exception, we think very highly. His treatise on "Factorials" bespeaks considerable analytical power; and though rejected by the Royal Society (which we deem to be no criterion of the merit of the work), it contains much that is new, and the whole system is developed with perspicuity and elegance. His "Arithmetic," again, is just what a treatise on arithmetic should be:—the rules are given clearly, and such reasons or approximations to reasons as could be comprehended by the minds of young students, are attached to the rules. The efficient demonstration of the rules of arithmetic constitutes the basis of algebra; for we hold that algebra is *fundamentally* only a statement of the rules for arithmetical operation, obtained by induction from the particular instances supplied in actual computation. We have no faith (because we have no proof) in the doctrine of "the permanence of equivalent forms," as a fundamental principle, apart from the evidence of induction, and of the verification afforded by deductions from it. Again, in the "Exercises on Mechanics and Natural Philosophy," Mr. Tate has manifested consummate skill, by exhibiting very simply and very clearly, the primary laws of mechanical action; and the exercises are admirably chosen from amongst the most familiar combinations of machinery, and the phenomena of daily observation, which tend to elucidate the principles very happily.

Our readers (and even Mr. Tate himself) must, then, be convinced that we are actuated by no hostile or unkind feelings towards that gentleman, when we express our objections, and very grave objections too, to his "Principles of Geometry." For no other reason, indeed, should we have said so much by way of proem.

Our objection then is—that Mr. Tate has either *misconceived* or *misrepresented* the fundamental character of geometrical evidence and of geometrical reasoning. Either of these charges seems almost alike improbable:—the former in consideration of his intellect, his reputation, and his cleverness; the latter, in consideration of his scholastic position and his high character for probity. We have no alternative to the one hypothesis but the other; and we have no hesitation in saying that *misconception* is the real cause of the objectionable principles of this work. We will state our reasons for thinking so.

Mr. Tate, like nearly all our "analysts," appears to have never acquired a clear view of the essential principles of geometrical evidence. Analysis (employing the word as synonymous with algebra, after the dictum of D'Alembert) is a system of inductions only—at least, as far as operations and what are called "principles" are concerned. Its most general theorems are wholly dependent upon induction for their evidence—as much so as the parallelogram of forces, or the law of gravitation. In geometry, on the contrary, the only *principle* employed is the syllogism; and the only *appeals to experience* are the few axioms respecting the visual and tangible properties of figures which are put down at the opening of Euclid's first book, together with those fundamental conceptions respecting multiples which are prefixed to the fifth book. The fact is, that Mr. Tate has not discriminated between the essential characters of geometry and of algebra; and he has thereby been led to import into the discussion of the former subject, the methods which are not only legitimately available in the latter, but in a great degree essential to its development.

There may be an additional reason, dependent on Mr. Tate's professional position, for his vagueness of conception on this head. The Battersea Training Institution was formed, we believe, for the purpose, not so much of education itself, as for training the humbler order of schoolmasters in the *art of teaching*. Most certainly the object was a noble one: for probably no one of our social classes stood relatively so low in respect to skill in their particular duties as the general mass of schoolmasters. A good teacher, or even a moderate scholar, was the exception to the rule rather than the rule itself. This has been sufficiently established by the reports of the "Government Inspectors of Education"—even after all allowance has been made for the over-colourings in those Reports, which in some cases cannot be denied to have been made. The formation of suitable schoolmasters, especially for the rural districts, required them to be trained to a ready and popular exposition of the ordinary phenomena of nature and of mechanism, as well as of mere methods of computation. Popular rather than technical language is often found to be convenient; and, below a certain grade of mental development, it is essential in such a case. In the devising of such popular modes of exposition, Mr. Tate has been for many years employed; and, as is always the case, his daily routine of duties may be supposed, without any diminution of our respect for his talents, to have destroyed that vividness of perception and rigorous spirit of reasoning, which mathematical science naturally produces in respect to the force of evidence.

We look, of course, to the preface of a work to ascertain the objects for which that work is written, and the principles on which the author composed it. A reference to Mr. Tate's preface, with one or two specimens of his method of proceeding, will, we are sure, convince every reader that we have not formed our unfavourable opinion of his work without adequate reason.

Mr Tate considers that "it will be instructive to trace the origin of *our ideas* in geometry, with the view of suggesting to us *the means whereby first notions on the subject should be conveyed to the mind of the learner*." Now, the ambiguity involved in the word "our"—which leaves it uncertain whether he referred to the conceptions of the first geometrical speculists of our race, or to those who in our time have been trained in the terminology and popular traditions of geometry—is very objectionable. The former would appear, from his subsequent remarks to be his view: but it is not at all clear. Under either aspect, however, his maxim is very questionable; and certainly by writers of the highest scientific and philosophical authority, it is always rejected. In truth, the actual order of discovery is almost invariably found to be the most inconvenient for the systematic exhibition and development of scientific truth. The universal history of science is at variance with this conundrum of Mr. Tate's.

The author's delineation of that creature of his brain, the primeval geometer, is a sufficiently ludicrous piece of seriousness: but his talk about "the vast amount of facts accumulated *independently of the formality of definitions, or the tedious verbiage of a rigorous demonstration*," really startles us. It is more like the raving of an illiterate person than the language of an accomplished geometer. Neither can this be called a stray passage accidentally expressed in an offensive form; for the *animus* is the same throughout the work. For instance, he says a little further on (p. vi.): "In the demonstrations contained in the following treatise, conciseness and simplicity have been preferred to *the artificial verbiage of a technical logic*;" and he has created his primeval and philosophical geometer, "without any precise views relative to *the origin of ideas*, or the *formulæ of a technical logic*, [with whom] demonstration would consist in a simple appeal to *common-sense*, or in such an exposition as might be sufficient to *carry conviction to the mind*." This primeval geometer is created, too, as the Battersea-pattern for the formation of Englishmen of science; and Mr. Tate has falsified Euclid's assertion as respects "a royal road to geometry!"

We wish, however, to ask Mr. Tate a question or two on these subjects. What does he mean by "common-sense" in connection with the acquisition of science? We often hear the phrase used, it is true, by men who call themselves "practical:" but as far as our memory goes, we have never heard it used by a scientific person in the way it is here used by Mr. Tate, though very often so by persons destitute of all science. In geometry we can attach no other notion to it than that it is intended to express the inference which we may draw from visual evidence, or from instrumental evidence at the least—in short, the evidence of experiment performed with the ruler and compasses, or perhaps with a somewhat sensible balance, such as those made by Bate, of the Poultry. Be it so—but do not degrade science by calling this "geometry."

Again, what does Mr. Tate consider to be "such an exposition as might be sufficient to carry conviction to the mind" of a learner? Judicious teachers, we have often heard, lament the imbecile facility with which conviction is carried to the minds of the most slothful pupils: they are most readily "convinced" by the bare words of the enunciation, provided they are excused the trouble of understanding it, and still more readily if they can be excused the trouble of proving it. Common-sense people, and people without any sense at all except the five physical ones, are alike adroit learners under these conditions; and it would seem that the founders of the Battersea Normal School knew pretty well what they were about, when they conceived that extraordinary scheme. Our own wonder is, not that Messrs. Shuttleworth and Tuffnell should have founded at college for such purposes:—it is, that Mr. Tate should not only have ministered to this extraordinary system of training schoolmasters, but that he should have pushed himself forward into such unenviable notoriety (for a scientific man) as the Coryphæus of a conspiracy for the abolition of pure geometry in England.

Let not the import of our remarks be misunderstood. We take no objection, but directly the reverse, to the composition of works on practical geometry, apart from the demonstrations of the processes. The Elements of Euclid were never intended as a work to serve the wants of the artisan or draughtsman in his operations; and it is very certain, that infinitely better constructions *for practical purposes* of the few problems given in the "Elements" might be easily framed. Their *proofs*, however, must depend on properties not laid down by Euclid. Yet it shows the paucity of resource which our "common-sense" geometers possess, when we remark that nearly all these writers follow in the wake of Euclid in the most servile manner, and adopt not only his constructions, but even their very order, and almost his language. Let us have a good work on practical geometry by all means: let the constructions be accompanied by demonstrations or not, as may be deemed advisable by the author; but still, let us not be beguiled into a belief that our constructions are true, by a few rambling, inconclusive, or utterly irrelevant sham-demonstrations,—alike discreditable to him who offers them as evidence as to him who so receives them. Give perfect demonstrations, or none. Take water, if you please, gentle reader, from the fountains of science; but do not pollute, or allow others to pollute, the pure streams with such adulterations as those which we shall presently quote from the work before us.

Mr. Tate does, indeed, pay some rather inflated compliments to the geometry of Euclid,—some "very fine writing," no doubt: but the very form in which they are expressed is obviously intended for disadvantageous contrast with his own system of primeval geometry. The only book, in the author's view, better than Euclid's is Tate's! In our view, the only book worse than Mr. Tate's is Mr. Andrew Bell's, in "Chambers's Educational Course"—not even Euclid's Elements excepted. After his eulogy of Euclid, he proceeds:—

> "However, it must be conceded, that whatever may be its excellences *as a book of reference to the mathematician, its defects, as an initiatory system of geometry, are too apparent to admit of even an apology.* A great book is, in many respects, a great evil; the very elements constituting its greatness,—its refinement and comprehensiveness,—tend to throw over it an air of mystery and dignity, which distracts and overawes the uninitiated student, in the place of giving him that encouragement and sympathy, which he certainly requires, in his first feeble efforts in the pursuit of abstract knowledge. The geometry of Euclid is a *highly artificial system, which can only be read, thoroughly, by a person who is already a mathematician, and who can enter into its metaphysical subtilties, and beautiful yet operose demonstrations.* The principle of motion gives a simplicity and clearness to many geometrical conceptions, but from an imagined inconsistency in the use of such a method, Euclid employs it, neither for the purpose of demonstration nor illustration. The *method of superposition*, which, in reality, lies at the very basis of geometrical demonstration, and, in many cases, *gives a graphic interest to an investigation*, is employed in the fourth proposition of his first book, and then, as *if ashamed of the lowly origin of geometry*, he scarcely uses it afterwards. *Many* of his problems are solved by methods which are never used in practice, for example, when a given portion is to be cut off from a straight line, instead of supposing the given portion to be simply transferred to, or placed upon the straight line, &c., which we really do in practice, Euclid must describe circle after circle, in order to accomplish the problem. The *doctrine* of similar triangles is, unquestionably, one of the most *important propositions* in the whole range of geometry, yet the student is not permitted to understand this proposition, until he has gone through the fifth book, which, to a large class of students, must for ever remain a sealed book. It is desirable that practical men should comprehend the leading propositions in solid geometry; *but Euclid's method of treating this subject, is so operose and refined, as to place it beyond the reach of persons whose time for study is limited, or whose mathematical talents are not of a superior order.*"

Now the gist of all this appears to be, that Euclid's Elements may do well enough as a "book of reference for professional mathematicians," but that it is preposterous to talk of it as a book suited to educational purposes, either for the masses, or for intelligent persons in general. It is represented as a great book, remarkable only for its metaphysical subtilty and operose demonstrations—for its refinement and comprehensiveness—and for the affectation of mystery and dignity which overawes and distracts the student. It is hard to conceive that such a description of the "Elements" could have proceeded from any man who has *read* and *understood* that remarkable production.

We deny in toto, the statement that the geometry of Euclid is "a highly artificial system," in the ordinary sense of the words, "that can only be read thoroughly by a person who is already a mathematician." If the order in which truths are capable of being successively deduced be a criterion of natural order, then the designation of artificial system as applied to the "Elements" becomes most signally inappropriate; and as to the structure of the syllogism (or rather enthymeme) in which Euclid delivers his reasoning, it will surely bear comparison, even for *real simplicity*, with the vague, unmeaning, slip-shod sentences which Mr. Tate has substituted in its place.

Euclid, it seems, was "ashamed of the lowly origin of his geometry"—viz. the method of superposition. Mr. Tate considers that it "gives a graphic interest to an investigation." Now, it surpasses our power to conceive what sort of interest a "graphic interest" is: but we suppose the author to mean that the mind is interested in having its own reasoning functions performed for it by the eye and hand conjointly. Even then we cannot understand on what ground mere superposition can be supposed to give *graphic* results. Did space allow, we could easily explain the cause of Euclid's sparing use of the principle, without suffusing the cheek or blanching the lip of the geometrical patriach with "shame."

As to the employment of the principle of *motion*, we have simply to ask, what advantages Mr. Tate thinks he can confer upon *accurate geometrical reasoning* by the introduction of it into geometry? Nay, more, will he tell us *how it would aid demonstration?* What organic definition would he give of a straight line? What could he get from the organic definition of the circle, which is more or less than Euclid's definition? Can he have forgotten that the cone, sphere, and cylinder are actually defined by their geneses? Can he have forgotten that the favourite method of superposition is not discarded from the subsequent parts of Euclid's Elements, where the principle could be made to facilitate the objects aimed at? We are sorry to come to the conclusion, but we can scarcely avoid the inference, that Mr. Tate has never "read and inwardly digested" the work which is the object of his animadversions—and we can have no scruple in concluding that he has never understood its objects, seized its import, or fully comprehended the system of philosophy of which it is one of the most enduring specimens.

Mr. Tate says that "*many* of his [Euclid's] problems are solved by methods which are never used in practice;" and he instances a *single one.* Can he instance *another?* We can with tolerable confidence answer for him:—that with this single exception, there is not a construction given in the whole range of the "Elements," of a problem which occurs in practical geometry, which we could not point out as being copied into recent, or comparatively recent works intended for the use of practical men. It is a perversion of the fact, and an abuse of the confidence placed in him by his readers, to make such unfounded assertions. That better *practical* constructions than many of them may be given, we have already said; but that does not affect the present case.

The objection that the doctrine of similar triangles is deferred so long, simply amounts to this: that proportion is made the fifth book instead of the first—which it might have been, and may, according to Euclid's treatment of the subject, be made to follow the third proposition of the first book. Would Mr. Tate obtain the doctrine of similar triangles without all consideration of proportion? On referring to his own way of treating the subject (p. 43), we find an illogical attempt to explain the idea of proportion, and to demonstrate the properties of proportionals. It is at best illustrative. If we must have similar triangles at an earlier stage of our geometrical career, it may be easily accomplished in a much better manner than this; for instance, as Legendre has done,—by assuming the doctrine of proportion as one already known and demonstrated by means of algebra. We do not ourselves recommend the method; but it has this merit, that it is all fair and open, and does not conceal the difficulty by a series of demonstrative evasions, which merely delude the pupil into a belief that the doctrine is proved, when no real proof has been given.

In the last place, Mr. Tate affirms that "Euclid's method of treating the solid geometry is so operose and refined as to place it beyond the reach of persons whose time is limited, and whose mathematical talents are not of a superior order." It is known to every one who is acquainted with the 11th and 12th books of Euclid, and the manner in which they are used in this country, that the first twenty-four or five propositions are as simple in their reasoning as the first book of the "Elements;" and that all the properties of solids which relate to volume or surface, form no part of our systems of academical reading. Mr. Tate must know this as well as we do; and we cannot consider it ingenuous to represent the difficulties which are inherent in the parts which are *discarded* from our usual systems of education, as attaching to those which are *retained*. Let us look to Mr. Tate's own work as regards these things. We find that with respect to the line and plane, he has nearly followed Euclid's views, leaving out however some *essential steps* of the demonstrations, and modifying some others after Legendre. Then, with respect to the others, which have in modern times been turned over to the calculus in some of its forms, Mr. Tate settles the question very summarily, by the aid of, we suppose, his "common-sense," or his "graphic interest." He settles it, in short, as "common-sense" usually does settle these things, by a gross mutilation of "the arithmetic of infinites." There is, indeed, no novelty in this: the only novelty is in seeing it done by any man who had previously acquired the title of a mathematician—and in our own day too!

We promised a specimen of Mr. Tate's tutorial scheme. Here it is:—

"Nearly all the geometrical knowledge contained in this work may be conveyed to the pupil in this manner.

Teacher. What is the line A B called? A———B

Pupil. It is called a straight line.

T. Of the two straight lines A B and D C, which is the greater? A————B D———C

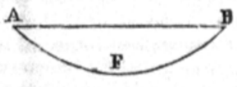
P. The line A B is the greater.

T. How should you ascertain this with certainty?

P. By laying the line D C upon A B.

T. What sort of line is A F B

P. It is a crooked line.



T. True; but it is also called a *curved* line. Whether is the curved line A F B or the straight line A B the shorter?

P. The straight line A B.

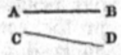
T. If you wanted to go from Battersea school to the church, in what line should you walk?

P. In a straight line. (Why?) Because a straight line is the shortest distance between the school and the church.

T. What have you to say relative to the two straight lines A B and C D? A———B C———D

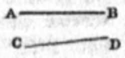
P. They appear to be of the same length; and moreover they appear to lie even with each other.

T. In other words you might say, C D = A B; and also C D is *parallel* to A B. Is C D now parallel to A B?



P. No; for C D would meet A B on the left side.

T. On which side would they now meet?



P. On the right hand side.

T. What is therefore the peculiar property or definition of parallel lines?

P. That if they be carried out ever so far, on either side, they will never meet.

A surface is called a *plane*, or flat even surface, when the line between any two points upon it is straight. Thus the surface of the table is a plane if a straight-edge exactly fits it when applied in every direction. To ascertain when a surface is a plane, bring your eye on a level with it, and if you find that every point in the surface can be seen at the same time, it will show that the surface is a plane. Our figures are supposed to be drawn on planes."

Such is the substitute propounded by Mr. Tate for the artificial *verbiage* of a "technical logic," and "the tedious *verbiage* of a rigorous demonstration," such as geometers give us! It is very possible that some readers may consider the substitute to be little else than the vulgar and illiterate *verbiage*, worthy only of the scientific charlatan, rather than of Mr. Tate and the Battersea Training College.

Were this book merely thrown on the market for those who may wish to purchase it, our concern would be less than it is about such a work: but we have heard that all the schools in England which are under the control of the Government Board of Education, are likely to have it forced upon them, as the condition of their receiving any part of the sums voted by the House of Commons in aid of those schools. The dedication of the work to Dr. Kay Shuttleworth is ominous; and the rumours which have reached us since we sat down to write, appear in perfect consistency with such a suspicion. Yet we can scarcely credit the rumour; and we believe that such an adoption of it would create a degree of dissatisfaction with that decision of that Board amongst scientific men and the friends of real education, which would be very disagreeable to the Government, and which might endanger its possession of the *patronage* which it is the policy of the Government to extend in all directions.

Oh, no! despite the misrepresentations and perversions with which the "Elements" is assailed, let us keep to the good old Euclid of our earlier days—unmutilated, and in his own venerable costume. The *true spirit* of geometry will be lost in England as it is elsewhere, if Euclid shall cease to be our text-book for the Elements of Geometry.

A Treatise on Practical Surveying, as particularly applicable to New Zealand and other Colonies, containing an account of the Instruments most useful to the Colonial Surveyor and Engineer, &c. By Arthur Whitehead, late Civil Engineer to the New Zealand Company. London: Longman, 1848. 8vo. pp. 196, with plates.

The title of this work sufficiently explains its object. The author, acquainted by experience with the particular difficulties and exigencies of colonial surveying, has here recorded a large amount of useful knowledge, which has probably been acquired amid many toils and hardships. To the English surveyor, accustomed to *well-cleared* country, the task of mapping-out the untrodden wilds of New Zealand must be a new and formidable undertaking. The greatest difficulties of surveying at home, sink into insignificance in the colonies. Here we have open country, and the use of the instruments is little impeded by obstructions to vision—there the thick forest closes in on every side, impenetrable to the eye and almost to foot of man. Here there are well-known way-marks and boundaries, of which every particular is already accurately ascertained and delineated—there everything is new and uncertain; the endless, unvaried scene presents nothing but intertangled thicket, without mark or vestige beyond the rare and fading traces of the hatchet of the savage. Here we have high-ways and bye-ways for chariots and horsemen—there the pioneer forces his way through a fence which is as thick as it is long. Or else his journey lies over the treacherous morass. Or he must swim the unbridged, unfordable torrent. Or his path mounts up the steep hill-side, with some 110° of Fahrenheit, and 45° of angular acclivity against him. No cheerful hostel for him where he may turn in to tarry for the night. He must not ask, with Falstaff, "May I not take mine ease in mine inn?" *His* inn is his blanket. His kitchen and larder are the basket which accompanies him at every step. To hap on a place where food might be obtained by barter, would be as surprising to him as to meet a policeman or postman. He pioneers without a road, and thinks himself fortunate if his course be along the mazes and rapids, the rocks and shoals, of a mountain stream.

It requires no ordinary energy to face such difficulties. And we may congratulate ourselves that the spirit of our nation renders Englishmen especially fit for occupations so arduous. The mania for enterprise which renders the English tourist the wonder or annoyance of the untravelled German or Italian, is turned to useful account when the wilds of the antipodes are to be marked out and plotted into farms and townships. Without this spirit there could be no sufficient inducement to begin this first attack upon nature. For these colonial surveyors are not civilizers, but the pioneers of civilization. They lead the forlorn hope. When they have made the breach practicable, others enter in and gather the spoil.

The first chapter of the work before us gives descriptions and accounts of the methods of adjusting the instruments chiefly employed in colonial surveying. For instruments used in the bush, portability is of course rather more important than it would be on the Sussex Downs. There are various risks from rough usage to be guarded against or remedied in the former situation which are comparatively immaterial in the latter; and on all these points our author gives minute instruction. Chapters II. and III. detail the methods of laying out town and country lands, and the particular objects which demand the attention of the explorer are carefully explained. The fourth chapter (on practical astronomy) does not from its nature admit much that is new, but appears to be a useful compendium. There are two other chapters, on marine surveying and colonial roads, and some tables of mean refraction, corrections for the sun's declination, &c. On the whole, we are inclined to think that when the English surveyor packs up for the colonies, he ought to put Mr. Whitehead's treatise in a accessible corner of his portmanteau.

IMPROVED MODE OF WORKING EXPANSIVE STEAM VALVES.

Communicated to the Mining Journal, by Mr. Thomas Craddock, *of Birmingham.*

Fig. 1 is an end elevation; and fig. 2 a side elevation. In this design, one eccentric, which is shown at 4, 4, 4, is made to give motion to both the steam and expansive valves. The time at which it is desired to open and close the expansive valve, in relation to the stroke of the piston, will be understood from the following description of the parts:—*a a* is the clip and eccentric rod, which communicates motion from the eccentric 4, 4, 4, to the expansive valve *n*, through the right angular lever *b* and *d*, which moves upon the pin *c*, which is attached to the small projecting parts *s s*, which project from the lever *f f*—the lever *d d*, terminating in a forked end, which takes into the groove of the circular ring *e e*, which ring is moved longitudinally by the action of the eccentric through the aforesaid lever *b* and *d*; *j* is another right-angular lever, which communicates motion to the expansive valve *n*, through the valve-rod *n′*. The part represented at *i i*, receives its support from the foundation, or other fixed part, to which the main shaft of the engine is attached, and has a projecting socket, on which the lever *f*, and ring *e* work—so that these parts have no direct communication with the main shaft. The ring does not revolve, but only partakes of the longitudinal motion imparted from the eccentric, and from thence through the levers *l* and *n′*, to the expansive valve. The arc of the part marked *i i*, supports the lever *f*—it being also graduated, indicates the point at which the steam is cut off; as it will be seen that, by moving the lever *f*, the whole of the parts *a a*, *b*, *d*, *h*, and *s s*, are carried round with it to any desired angle in relation to the main crank of the engine, whereby the same thing is effected as if the eccentric 4, 4, 4, itself were moved round, which governs the time of opening and closing the expansive valve. The part marked *h h*, is attached to the lever *f*, and serves the purpose of steadying the eccentric clip, and also embraces the arc *i*, so as to keep the lever *f* firmly attached thereto. At *q* is seen a small lever, acted upon by a spring, having at the opposite end a pin, which, on passing through the lever *f*, and arc *i*, holds the lever *f* firmly in the desired position; whereas, on pressing the smaller lever with the hand, the lever *f* is liberated and moveable: 3, 3, is the eccentric clip, which is supposed to work the steam valve.

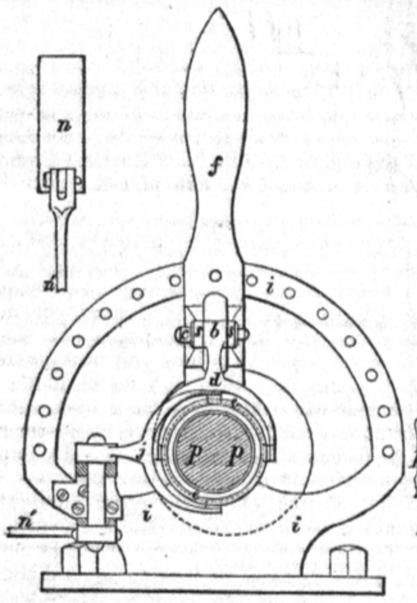


Fig. 1.

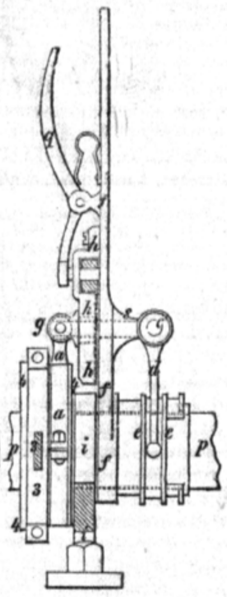


Fig. 2.

LLANDAFF CATHEDRAL.

The History, Present Condition, and Proposed Restoration of Llandaff Cathedral. By Mr. T. H. Wyatt.—(Read at the Royal Institute of British Architects, March 20.)

Upon the history of the cathedral, I shall not detain you at any great length. The first bishop is stated to have been Dubritius, who died in 522, on an island off the Caernarvonshire coast, and whose bones were in 1120 translated to Llandaff by Bishop Urban, the founder of the present cathedral.

Urban was consecrated the thirtieth bishop of Llandaff in 1108; and to him all concede the honour of having founded the present cathedral. At his first coming, he found his bishopric in a very poor and miserable condition,—the church razed almost to the ground; and complaining thereof to the King and the Pope in 1119, he procured letters and gathered large sums together; he pulled down the old church, which was but 28 feet long, 15 feet broad, and 20 feet high; and in 1120, according to Leland and Godwin, —or in 1129, as stated by Dugdale,—he commenced the fabric dedicated to St. Peter and St. Paul. Bishop Godwin (who wrote in 1601) describes this building as "a very elegant one, 300 feet long, 80 feet broad, and adorned at the west end with two stately towers of great height, and a neat chapel of our Ladye: a work truly magnificent, and to be remembered with honour by posterity." Urban died in 1133, whilst travelling towards Rome. From this period to the beginning of the last century there is no further record of any kind that I can find relating to the cathedral, and here conjecture must commence.

If Bishop Godwin be correct in supposing the church commenced by Urban to have been completed by him with two towers and a Ladye chapel, and to have been 300 feet long, it must have disappeared between the period of his death (1133), and 1180 or 1190, which will, I think, be conceded as the earliest date at which the present Early English structure could have been commenced. The extreme length of the present building is only 260 feet, and its breadth 76 feet. Of pure Norman work, such as we may believe Urban to have executed in the beginning of the twelfth century, we only have the large arch between the presbytery and Ladye chapel; the remaining portion of a window on the south side of the presbytery, so curiously stopped up at a later period; portions of a Norman string-course, with a fret ornament, running round the walls of the presbytery (being the string-course of the Norman clerestory); a variety of Norman fragments walled into the presbytery; and the two doors at the west end of the north and south aisles, which, though later in their detail and finish than the large arch, may fairly be considered as of Urban's time, particularly if he commenced at the east end and worked westward toward these doors.

The size of the chancel arch, and the importance and decoration of the aisle doors, clearly prove that they could have formed no portion of the early and insignificant church knocked about by the Normans, and eventually demolished by Urban; for although the preservation of doorways and chancel arches of Norman churches, rebuilt in the thirteenth and fourteenth centuries, is of frequent occurrence, yet in this instance I think they must have originated with Urban and not have been removed or perpetuated by him.

The character and finish of the large arch at the east end of the presbytery, clearly proves that it must have opened into a chancel or Ladye chapel: and thus we may believe Urban so far to have realised Godwin's description as to have completed, "a neat chapel of our Ladye." And the existence of pure Norman work, so far westward as the two aisle doors, may be taken as presumptive evidence that Urban completed "a work truly magnificent, and to be remembered with honour by posterity," even if his western towers were fabulous. Certainly these doorways are of rich and beautiful design, and the general character of all the Norman work remaining is of a pure and good period, corresponding with Urban's prelacy. What befel this Norman church, or how it could have been so completely destroyed in the short period between Urban's death and 1180 or 1190, as to have rendered necessary the almost entire rebuilding of the church in a new and distinct style, remains a mystery. Here are no traces of that gradual and clearly-marked transition from Norman to Early English, which we find so evidently and so instructively displayed at Canterbury, Norwich, Gloucester, St. David's, and Buildwas Abbey. With the single exception of the western doorway (in which the circular arch is retained, though the detail of the shafts and mouldings are Early English), the new work was commenced free from any taint or prejudice of a past style, and stands forth as pure and beautiful an example of Early English composition and detail as any with which I am acquainted. An able writer in the *Ecclesiologist* thus speaks of it:—"The exquisite Early English work of this part of the church is truly beautiful; not the least idea is obtained by the wretched drawing given in 'Winkle's Cathedrals.' To stand opposite the western front—itself once a marvel of art—and view through the now vacant and ruinous windows the paganized nave beyond it, with its flat pedimental roof, its ridiculous vases and urns, its stuccoed walls, is inevitably to feel the most forcible contrast between the speaking graces of the Christian and the burlesque absurdities of the revived pagan style."

Although from the affinity of England to Wales, where our ancestors sojourned, if not as absolute conquerors, yet as authorised visitors, we may fairly believe architecture to have been almost on a level in point of date, we can have no reason for imagining that the Welch were some 70 or 80 years in advance of the English in the periods of their architecture, or that the change from the circular to the pointed arch, by us called "Early English," should more properly have been called "Early Welch." If this is allowed, I am unable to believe that any antiquary can assign an earlier date than 1180 or 1190 to the west front and nave of this cathedral; for though it is perfectly impossible to fix with peremptory certainty the exact date when one particular stage or style of art ended and another commenced, yet we find that from the period when the pointed arch first made its appearance and became blended with the Norman semicircle, years elapsed before the newer style or form had shaken off the influence of its predecessor.

We find in numerous instances, as at Gloucester, Canterbury, the Temple Church, and St. David's Cathedral, that this transitional feeling existed in full force—nay, that the Norman preponderated—although the portions I allude to are well known to date about the end of the twelfth century. You will, I think, share my disbelief in the theory that the pure and pointed work at Llandaff could have been commenced sixty or seventy years before the Norman arch had elsewhere ceased to prevail. In Buildwas Abbey, which is one of the earliest transition works I know (the date of which is stated to be about 1135), the indication of Early English form or feeling is very slight. In the section of one of the bays of the nave of St. David's Cathedral, built in 1180, you find the only Early English work consists of a small arcade, between two series of clearly-defined Norman arches!—certainly not a very convincing proof that Early English work was in existence in the sister cathedral of South Wales sixty years before this work was commenced.

Henry (prior of Abergavenny) was consecrated bishop of Llandaff in 1191, and died in 1218. He may, with at least as much probability as belongs to some antiquarian assertions, be supposed, if not actually to have recommenced the erection of his cathedral in the new style of his day, at least to have promoted works, the character and period of which are so evidently coeval with his twenty-seven years of power.

The lower portions of the north tower, and all the remaining part of the south tower, the nave, and clerestory remaining, are all of the same pure Early English character. In the columns and arches of the nave and choir a slight variety of arrangement occurs without deviating from the style: somewhat more ornament is introduced, and by the time they reached the Ladye chapel, the gradation of style becomes apparent; and with a view to give increased richness to this more sacred portion of the building, or from the more "decorated" fashion of the day, when they arrived thus far east, vaulting is introduced, mullions and circles are executed in the side windows, and in the easternmost window tracery becomes apparent, until it almost assumes the character of a "decorated" window.*

In the two bays of the presbytery a fault (as geologists might term it) occurs, which it is difficult to account for. These arches are evidently of a later and more depressed form than those in the nave and choir, and from their form and detail are of a later date than the Ladye chapel. Whether this portion of Urban's work may have remained uninjured and undisturbed until after the completion of the Ladye chapel, when they may have thought it necessary to assimilate the Norman piers and arches more closely to their pointed neighbours, or whether some injury took place to this part of the cathedral, which rendered rebuilding necessary at a later period, I have no means of determining, but it is curious that in this portion of the building we find more Norman remains than elsewhere. There still exists the Norman string-course in its original bed, with a sort of "embattled fret" carved upon it, running round the three sides of the presbytery: we find plinths and portions of cylindrical shafts, which may have formed (as at Norwich) the arch between the choir and presbytery: there is the large Norman arch over the screen; the curious remains of a Norman window, so unceremoniously blocked up by the Early English architect who built against it; and in the rough masonry of the walls of this part we find walled-up numerous fragments of Norman mouldings and ornaments. One might almost suppose this portion of Urban's original cathedral to have escaped the early destruction I attribute to the rest of his building, and to have been preserved intact by the Early English architects who rebuilt it. At some later period, for fashion's sake, or from decay, we can imagine these arches to have been reconstructed or remodelled, leaving, as I believe they did, the Norman clerestory undisturbed. The string-course even now remains; and in the view given of the north front by Godwin, in 1713 (when it was almost perfect), it will be observed that a semicircular and apparently Norman line of windows is shown in the clerestory of this part, as distinguished from the Early English in the nave. Of the history of this alteration or portion of the work, I can find no trace.

The "decorated" altar-screen is stated, in Browne Willis's, and all the other histories of the cathedral, to have been erected by a Bishop Marshall, who was consecrated in 1478; but as the detail is pure "decorated," it must have been completed, in all probability, 100 years before this time. I have little doubt but that the piers and arches of the presbytery and this screen were erected at the same time, or by the same architect—an opinion which is confirmed by the fact of the base moulding on the south side being raised considerably above the opposite pier on the north side, and corresponding exactly with the level of the base of screen and the base of the sedile which it immediately adjoins. The decoration and enrichment of this screen, attributed to Bishop Marshall, have, no doubt, reference to the painting and gilding upon it. "There are eleven niches in the principal level, painted with roses and hyacinths interchangeably." The centres of the roses and flowers of the hyacinths are gilt. The roses are white (which quite identifies the decoration with Bishop Marshall),—the white rose being the device of the house of York, used for decoration only in the reign of Edward IV. and Richard III. Bishop Marshall having been preferred to this diocese by Edward IV., the adoption of his badge was a natural and proper compliment. "Under these eleven niches is a row of eight niches, painted in fresco, exactly like the former. At each end of these are three real niches painted in the same manner; within these are two little ones, with a pilaster between; the ground-work throughout is interchangeably blue and red, and the ornaments over all the niches are gilt. At each end is a door leading into a vestry." Thus far I can confirm, from the remains of this screen, the description given by Browne Willis. He then proceeds to say—"Above the altar-piece are two rows of large niches, in which formerly there have been figures. In both rows the middlemost niche is larger than the rest; and on each side are two lesser ones. The two largest niches probably contained the images of our Lord and the blessed Virgin, and the other twelve were for the twelve Apostles. Under the two large niches are the ten commandments, written with gold letters, within a frame, and over all is a handsome freestone window." Unfortunately, the destruction of this upper portion of the screen has been complete (doubtless the work of puritan or political fanaticism). Nothing remains above this line, but we have found walled into the various portions of the structure fragments of corbels, canopies, and buttresses, which evidently, from their size and form of moulding, belonged to this screen.

From the period when Godwin described Urban's church to have been complete, of certain dimensions, and a work truly magnificent," there is no notice of the cathedral until 1719, when Browne Willis, an antiquary of that day, as he says, "collected together various records and matter, and gave with his work certain draughts of the said church, in order to illustrate the descriptions thereof." These draughts, as you may imagine, are not very clear in their distinctions of style, or in the best possible perspective, but they are most valuable as helping the description, as being the only records we have of what the old cathedral was (before lightning, storms, and Wood of Bath played such havoc with it); and, consequently, as being our principal guide and authority in the restoration. It was then falling into a state of deplorable decay, though perfect in its internal arrangements. There was a large building in front of the south Norman doorway, which he calls the "Consistory Court;" and a porch opposite the "decorated" south door. Both these excrescences have disappeared, and I should much doubt if they formed any portion of the original design.

Soon after Browne Willis's survey, destruction had full sway. On the 20th of November, 1720, the remaining battlements and pinnacles of the north tower (which had escaped the storm of 1703) were blown down, and destroyed a considerable portion of the north aisle. On the 6th of February, 1722, the "roof and floor of the south tower fell in, and destroyed a good deal of the church." The complete ruin of this old structure must have followed very rapidly on Willis's visit; and in 1724 we find the Archbishop of Canterbury interesting himself in its proposed rebuilding (I cannot say restoration). He obtained 1,000*l*. from George I., and, like our bishop of the present day, tried in vain to get anything from the Prince of Wales. Sufficient funds were, however, eventually raised to erect the frightful shell which now encases the original piers and arches.

About 1735, Wood of Bath, commenced the desecration of this find old work, and of his own prior fame: for most assuredly a more barbarous or tasteless grafting of uncongenial modernism upon an ancient stem was never perpetrated; and never was the sarcasm of the historian Whitaker more justly deserved than in this instance. He says—"The cloven foot will appear! for modern architects have an incurable propensity to mix their own absurd and unauthorized fancies with the genuine models of antiquity! They want alike taste to invent, or modesty to copy." All that can be said in extenuation is that the corrupt taste of that day gave a fashion to this work, the power of which Wood may have been unable to resist; I wish it was in evidence that he had tried to do so. That this fashion approved such barbarism may be inferred from the accompanying letter, which I find copied in the "Cole's MSS." in the British Museum. It is written by a Rev. Thos. Davies to Browne Willis, who appears still to have taken much interest in the old wreck:—

"23rd Nov. 1736.—The church on the inside, as far as 'tis ceiled and plastered, which is something beyond the west end of choir, looks exceeding fine, and is a very stately and beautiful room. The area of the whole church is to be considerably raised, so that when finished it will (in the judgment of most people who have seen it) be a very neat and elegant church, unless, indeed, the altar-piece, which looks like a huge portico, spoil the whole effect."

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* There is good reason to believe that the Ladye chapel was the addition of William de Breos, the forty-third bishop, from 1266 to 1287. He was buried close to the altar, and his tomb still remains.

Mr. Cole illustrates his amusing MS. by elevations of the west and south fronts, and a view of the altar portico, which it was feared (and not without some reason) might mar the whole effect.

We find no traces of the portico at the west end, nor can I learn that the pigeon-house cupola was ever carried into effect. The altar was removed some few years ago.

The bishop's throne, the pulpit, and stalls consist of an Ionic colonnade, with niches at the back; they still exist in their pristine propriety and beauty, and I can conscientiously recommend them to any architect about to build assize courts; the pulpit and throne would form admirable judge's seats, and the stalls a most dignified row of seats for the magistracy.

I do not imagine that much was done to Mr. Wood's structure until 1840, when the plaster ceiling and lead over the nave being in a very bad and unweathertight condition, a considerable sum was expended in repairing and making good as it then existed.

So much for the history of the cathedral. A very few words will describe its condition when the present restorations were commenced.

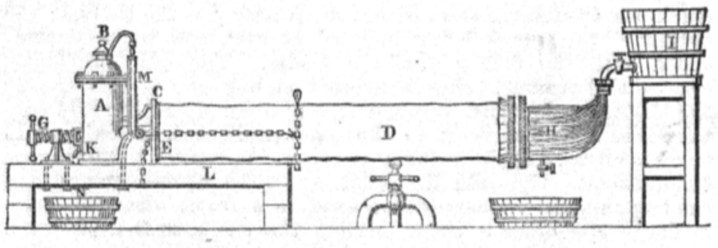
REGISTER OF NEW PATENTS.

PRESERVING AND COLOURING WOOD.

Francois Augustin Renard, of 40, Rue du Rocher, Paris, merchant, for "*Improvements in preserving and colouring wood.*"—Granted August 19, 1847; Enrolled February 19, 1848.

This invention consists in a mode of constructing apparatus in which a vacuum can be produced, after the same has been applied to one end of a log of wood; so that a preserving or colouring liquid, contained in a suitable vessel or receptacle at the other end, will be caused, by atmospheric pressure, to pass through the log in the longitudinal direction of the fibres.

The annexed engraving is a side elevation of the apparatus employed. A is a metal cylinder, provided with a top-piece B, from which is suspended a rod, with a piece of perforated metal or wire gauze attached to its lower end. C is a metal disc, fixed to the cylinder A, having an opening at its centre, communicating with the interior of the cylinder; and between this disc and the end of the log of wood D, a narrow leather washer E, is interposed, so that there will be a small space left between the log and the disc. The position of the log upon the frame L, is to be adjusted by the chain and the screw G; F is a collar, placed around the log of wood, having a chain attached to it, and by which the wood may be moved to and fro, as required, upon the frame L, by means of the screw G: in turning the screw, by means of the lever, the chain will act upon the collar F, either to bring the block nearer or remove it farther away, as may be required. The other end of the log is enclosed in a bag H, of impermeable material, which is connected to the cock of a vessel I, containing the preserving or colouring liquid. Now if a vacuum be produced in the cylinder A, the pressure of the atmosphere upon the surface of the liquid in the vessel I, will force it through the log. The vacuum may be obtained by any convenient method; but the patentee prefers to produce it by dipping the wire gauze, carried by the rod of the top-piece B, into some inflammable matter (such as alcohol), and introducing it in an ignited state into the cylinder A; the air will then escape through the cock K, which is to be left open for that purpose, and is to be closed as soon as the required vacuum is obtained, as indicated by a small barometer M, connected by a tube with the interior of the cylinder A. When the moisture of the wood, or the preserving or colouring liquid, has been forced by the pressure of the atmosphere into the cylinder A, the vacuum will be destroyed, as will be indicated by the barometer M; the cock K being then opened, the liquid will run into a vessel N, beneath; after which, a vacuum is to be produced in the cylinder A, as before.



The passage of the liquid through the log may be accelerated by a force-pump or other suitable means. Although the log is shown in a horizontal position, yet it may be operated upon in a similar manner when in a vertical position, by substituting for the bag H, and vessel I, a vessel with a suitable opening in the bottom of it to receive the end of the log. When the log or piece of wood is square, then, instead of the bag H, and vessel I, a trough is used to contain the preserving or colouring liquid, and the whole of the log is immersed therein, excepting the end to which the metal disc is applied.

REFINING SILVER AND LEAD.

Arthur Harry Johnson, of Gresham-street, City, assayer, for "*Improvements in refining silver and lead, by effecting a saving in one of the materials used.*"—Granted September 23, 1847; Enrolled March 23, 1848.

The improvements consist in restoring after use, and rendering again available, the phosphate of lime or bone-ash, whereof the cupel or test used by refiners of silver lead is composed, and in the process saturated with lead, and a portion of silver. For extracting this lead and silver, the course usually adopted is to return the used cupel to the furnace, by which means the whole of the saturated bone-ash is destroyed; while portions of the lead and silver, combining with the phosphoric acid of the bone, pass off, and are lost. By the improved method, little or no waste occurs of either the bone-ash, silver, or lead.

To carry out the invention, a solvent of the oxide of lead is used in the following manner:—First reduce the used cupel to a fine powder; then add a sufficient quantity of pyroligneous or acetic acid, varying from 1·009 to 1·048 specific gravity, according to the per-centage of lead contained, to render it of a thin consistence, that it may be thoroughly stirred in a dolly-tub, or some such convenient machine, or by allowing the acid to percolate through the powdered test. After allowing the powdered cupel and acid to remain together for two days (during which time occasionally stir them well together), the bulk of the lead becomes dissolved. The mixture is next put into cloth or flannel filters, or other percolators, to allow the lead solution to drain off; this done, remove the remaining soluble salt of lead, by washing it with water and by the application of pressure, previous to drying the resulting bone-ash.

After the above process, the silver, and some lead, still remain in the bone-ash, though not sufficient lead to materially interfere with its absorbent powers, on again using, provided it has been properly freed from the lead solution. If, however, it be wished to extract the lead more perfectly, add a second portion of the acid to the filtered or drained bone-ash, and again thoroughly stir it in this second acid—the washing and pressing, as before described, following this second operation. To bring the lead, contained in the solution, into a marketable form, after due saturation, either simply evaporate it in proper pans to make sugar of lead, or by means of the several re-agents commonly employed, form respectively the carbonate, the sulphate, the sulphuret, or other compounds of lead that may be desired.

Instead of pyroligneous acid, a solution of caustic potash may be used, or soda, containing about 20 per cent. of the pure alkali; but this has not been found so useful in practice.

GAS STOVE.

William Brockedon, of Devonshire-street, Queen-square, Middlesex, for "*Improvements in heating rooms or apartments.*"—Granted September 9, 1847; Enrolled March 9, 1848.

This invention relates to heating rooms with gas. It consists in so constructing stoves or fire-places which are open in front that gas may be burned therein, and the decomposed air and products of combustion pass into chimneys, as from open fire-places or stoves when burning coal. The stove or fire-place may be constructed as nearly as may be like those now used with open firebars, and may have a bottom grate similar to what are used for burning coal, and they may be made to fit the fire-places as at present constructed, or the stoves and fire-places may be greatly varied in design, so long as the stoves or fire-places are capable of consuming gas in an open fire-place communicating with a chimney or flue.

In order to give a gas stove constructed according to this invention, as much as possible the character of the present open fire-places used for consuming coal, they are to be made with a front grating or bars, against which is to be placed lumps of pumice-stone or other substances which will allow of being heated by the flame of gas and yet not consume. The front bars should be made nearer to the back of the stove than when for burning coal, and so that there shall be but small space between the back of the stove and the front bars; or such substances may be placed in a wire or other frame suspended near to or amidst the flames of gas where the form of the stove or fire-place is not otherwise adapted to receive such substances; and in some cases the front bars of the stove or grate are made hollow, so as to allow gas to pass from a supply-pipe into them, and thence to pass out through perforations so as to produce numerous small flames which may be partly inward towards the pumice-stone, so as to heat the same, and other flames may be outwards through between the front bars of the stove or grate, and the front bars in place of being simply across the fire-place may be made into any fanciful form, such as basket work or otherwise, to hold the pumice-stone, or other substances. Or in place of having the front bars or open grating hollow and perforated to produce numerous jets of gas, the jets of gas may be wholly or partially from the bottom or the back or sides of the open fire-place or stove. And it should be understood that it is essential to this invention that the apparatus should be open to view, and also be open to a chimney or flue, so that the gas in burning may give heat to the room or apartment without the decomposed air and products of combustion caused thereby coming into the room or apartment, and at the backs and sides of such stoves or fire-places, bright steel, glass, china, or other reflectors, may, with advantage, be placed. It is not essential to this invention that the open gas fire-place should have a receptable for the pumice-stone or incombustible substances, as the same may be dispensed with, but it is preferred to have an arrangement for receiving such substances, as thereby the cheerful character of the old English fireside is retained. And the inventor believes that the most elegant result may be obtained by using jets of gas from front bars or grates combined with jets of gas from bars or apparatus at bottom, so arranged that air may (as is now the case when burning coal) pass up between the bottom, the lower bars in such case supporting the pumice-stone or other substance, for by such means, by a comparative small consumption of gas, the appearance of a large flaming fire may be produced.

JENNINGS'S PATENT INDIA-RUBBER TUBE COCKS.

This improved cock is made by placing a flexible india-rubber tube of any required size within one of metal, as shown in fig. 1; and then by mechanical means to flatten the flexible tube, as shown in fig. 2.

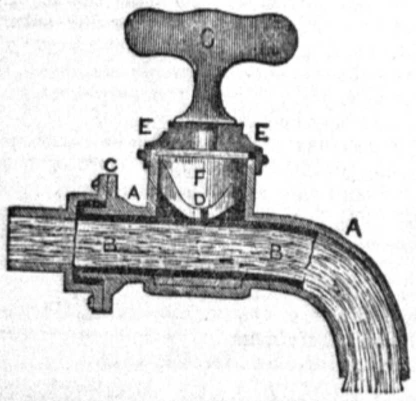


Fig. 1.

The advantages which the patentee states this cock possesses over any at present in use are—1st. The ease with which it can be at all times opened or shut, and the means used for that purpose being so simple, it cannot be set fast by corrosion or become injured by frequent use. 2nd. When open it is part of the main or pipe, as shown in fig. 1, and presents the same uninterrupted passage as the pipe itself, and as the means used for closing or stopping the circulation have no communication with the gas or water passage, leakage is impossible. 3rd. It will be seen by fig. 2, if the vulcanised india-rubber tube be properly flattened the cock must be sound. 4th. These cocks are capable of standing any pressure, as the elastic material of which the cock is composed never can become injured by pressure, as long as the metallic casing which surrounds the flexible tube remains perfect.

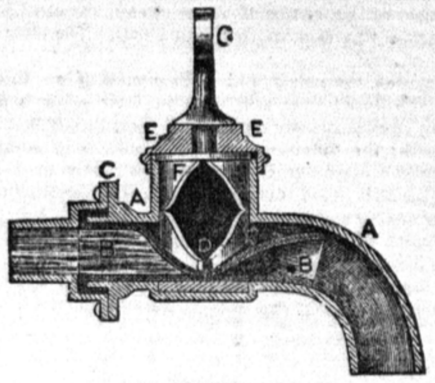


Fig. 2.

SEPARATING IRON FROM ORE.

Arthur Wall, of India-row, East India-road, Middlesex, for "*a new or improved apparatus for a method of separating oxides from their compounds and each other.*"—Granted October 14, 1847; Enrolled April 14, 1848.

The apparatus is for separating iron from the ores of copper, &c., and consists of two hexagonal drums with an endless chain passing over them, made by connecting with links a number of horse-shoe magnets; on the extremities of each of the magnets a number of steel blades are so fixed as to stand out at right angles to the magnets. These drums are made to revolve over a trough in such a position that while the chain of magnets passes immediately above the trough the steel blades reach nearly to the bottom; the bottom of the trough being inclined at each end, so as to correspond with the direction of the blades. The ore (previously roasted and ground) being introduced at one end of this trough the blades, as they pass through it, will take up all the iron contained in it and carry it to the other end; and, indeed, would bring it all back again in the next revolution but for the following arrangement. Opposite the point where the blades emerge from the trough, a set of magnets are fixed to a frame with their poles in the reverse order to those forming the chain, so that when the steel blades come opposite these fixed magnets, their magnetism is neutralised, and the iron which they had collected in the trough falls off, and is collected in another trough placed beneath to receive it. The patentee does not confine himself to the permanent magnets, but he claims also the use of electro-magnets, though he prefers to use the former as being more convenient.

Plate-Glass.—Patented October 7, 1847, by **James Hartley**, of Sunderland. The improvements relate to the manufacture of rough plate-glass immediately prior to the pouring of the melted glass or metal upon the table, and rolling.—Instead of lading the melted metal into a separate cistern as usual, the patentee lades it direct from the melting-pot to the pouring-table, where it is immediately poured and rolled. The patentee employs, for the purpose of lading the melted metal, should the quantity required be large, two or more ladles; and he states, it is not absolutely necessary that the whole should be poured at the same moment upon the table; but the second ladle may commence to be poured at nearly the termination of the pouring of the first ladle. After the manufacture of the rough plates, they are to be piled and annealed in the same kind of furnace and in the same manner as crown or sheet glass, thus dispensing with the more expensive annealing furnaces employed for plate-glass.

PORCELAIN KILN.

Alfred Vincent Newton, of the Office for Patents, 66, Chancery-lane, Middlesex, mechanical draughtsman, for "*an invention of an improved kiln or oven, for firing porcelain and other similar ware.*" (A communication.)—Granted July 29, 1847; Enrolled January 29, 1848. [Reported in Newton's *London Journal.*]

The inventor, in order to explain more fully the nature of his improvements, has prefaced his specification with the following observations, explanatory of the ordinary mode of firing or baking hard porcelain, and the difficulties and objections incident thereto.

The employment of pit-coal as a fuel for firing or baking *hard* porcelain has hitherto been thought impossible, or at least subject to almost insuperable difficulties. It was thought that the hardness and infusibility of the clay (kaolin), and the high degree of heat necessary to fuse or melt the glaze which is employed to cover hard porcelain, were insurmountable obstacles. A long and sufficiently large or extensive flame to occupy the whole space of the oven or kiln is indispensable for this kind of manufacture; and the liability of the matters composing the hard porcelain to become discoloured, rendered this superabundance of flame the more necessary, in order that no smoke might be allowed to remain in the kiln or oven. It is requisite, therefore, to cause pit-coal to develope such an amount of flame as would have the same effect, and would act within a given time in the same manner as wood.

The matters of which hard porcelain is composed, are divided into two classes,—first, the paste or clay, which is a principal element; and second, the glazing or enamelled covering. The paste or clay consists essentially of two elements; the one is an infusible argillaceous matter,—this is kaolin, either alone or mixed with plastic clay, or with magnesite,—the other, arid and infusible, is given by felspar or other stony minerals, such as siliceous sand, chalk, or gypsum, either separately or mixed together in different combinations. The enamel or glaze consists of quartzoze felspar, sometimes alone and sometimes in combination with gypsum, but always without either lead or tin. Hard porcelain must, in fact, be considered as hard compact impermeable pottery-ware, which is essentially translucid, and ought not to be confounded either with stone-ware, delph-ware, pipe-clay, or even with the ordinary tender English porcelain. The kilns or ovens for firing or baking hard porcelain are generally cylindrical, and divided into two chambers or laboratories, one placed above the other. The upper laboratory is supplied with heat from the flame of the lower laboratory, and serves to warm or heat the articles, which, when taken from thence, are dipped into the glazing composition, and afterwards exposed to the great heat in the lower laboratory, which may be properly said to constitute the kiln. The fusion of the glaze or enamel, as is above said, requires a very high temperature; and it is in the laboratory where this operation is carried on that the temperature is raised to the highest degree. In both these laboratories the articles must be inclosed in fire-clay vessels or seggars, which should be carefully closed, in order to prevent the admission of deleterious matters. The necessary amount of flame and heat may be obtained by increasing the number of fire-grates and openings for the flame: thus a kiln or oven, six yards in diameter, which, when heated with wood, requires six openings, must have ten when pit-coal is employed. A kiln or oven, five yards in diameter, would require only five fire-grates for wood, but must be furnished with eight for coal. A kiln or oven, four yards in diameter, heated by wood, would require four fire-grates and apertures for wood, but must have six for coal. In order to make the flame sufficiently long and abundant for the requirements of the manufacture, the combustion ought to be supplied with a double draft, or additional currents of air. Thus, besides the supply furnished between the fire-bars from the surrounding atmosphere in the workshop, air obtained from outside is conducted by horizontal channels to the fire: that is to say, besides the ordinary supply of air, an additional quantity, obtained from the external atmosphere, is made to act with energy on the fires in the grates. By this means, the kiln is supplied with a very large and superabundant supply of air, which furnishes the fuel with a much greater quantity of gas to decompose.

The engravings represent a kiln or oven, constructed according to the present improvements; and it should be observed, that it is always easy to obtain the necessary quantity of air, by taking it from the atmosphere of the workshop, either by having an aperture or grating at the end of the ash-pit, or by making openings below the fire-bars in the two side walls of the furnace.

The improved system of firing or baking may be applied to all kilns, whatever may be their form or dimensions; and, by means of a double roof in the upper laboratory, hard and tender porcelain may be fired in the same kiln simultaneously: that is to say, hard porcelain may be baked or fired in the lower laboratory, at the same time that tender porcelain or common earthenware is being fired in the upper laboratory. In manufactories where at present the baking of biscuit-ware and glazed ware is carried on in separate kilns, it will be evident that these kilns may, by the application of a double roof, be more advantageously employed in the following manner:—In the biscuit kiln, heretofore employed, delph, or earthenware, or unglazed tender porcelain, may be operated upon in the lower laboratory, while hard porcelain may be dried and heated in the upper laboratory; and in the other kiln, formerly used for glazing, the hard porcelain should, on the contrary, be placed in the lower laboratory, to be baked or fired; and glazed delph, or earthenware, or tender porcelain, may be operated upon in the upper laboratory,—the heat in which will be found sufficient for this kind of ware.

The kilns being furnished with the required quantity of fire-places, the combustion must be kept up, by supplying an excess or superabundance of air, obtained either from the external atmosphere or from the workshop, and supplied in some convenient and suitable manner, depending of course upon the situation of the kilns, their peculiar construction, and other circumstances. The fire should be gradually supplied with fuel, at first at long intervals, then at short intervals. The state of the fire-place should be looked to carefully, for it is the rapidity of the combustion of the coal which indicates the quantity of fuel that is required, and the moment when the charges are to be thrown on quickly. The fire-places must be well watched, for the purpose of levelling the fuel, so that the fire-bars may be suitably and evenly covered, and that air to support combustion may always find a proper passage. It is also necessary to rake the fire frequently, in order to clear out the cinders, and to prevent the fire-bars from getting foul, and to remove clinkers therefrom, which would otherwise stop or diminish the combustion. Holes through the mass of fuel should never be allowed to exist, and the flame should always be well watched; and the baking or firing operation always be carried on with a long flame. All these precautions are necessary, in order to obtain very pure and white porcelain, as the defects of the firing operation arise most frequently from the want of a proper flame.

Fig. 1 represents a transverse vertical section, taken through the centre of a kiln of the improved construction; and fig. 2 is a horizontal section or plan of the same. *a* is the outer chimney or flue of the upper second laboratory; *b* is an upper chamber, which may be used for drying or heating; *c* is a roof (shown by dotted lines), which will be required if it is intended to bake or fire both tender and hard porcelain in the same kiln; *d* is the flue of the lower chamber or laboratory; *e e* are passages or openings, of which there are the same number as there are fire-places in each kiln; these passages should be placed between the fire-places, and open a communication from the lower to the upper laboratory. *f f* is the lower laboratory, where the principal firing or baking operation is carried on; *g g g*, are the fire-places; and *h h h*, openings, to allow the flame to pass therefrom into the interior of the kiln. *i i*, are the fire-bars; *j j*, the fire-doors; *k*, the ash-pit; and *l l*, passages communicating with the ash-pit from the external atmo-

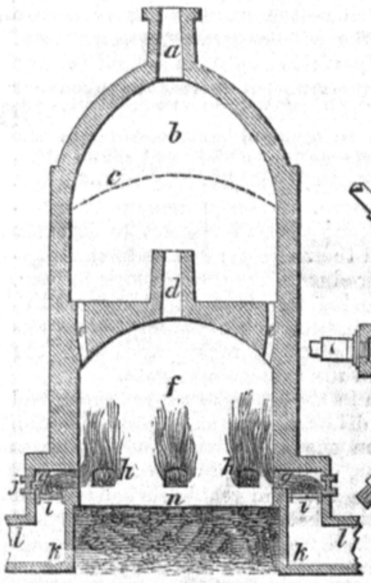


Fig. 1.—Section.

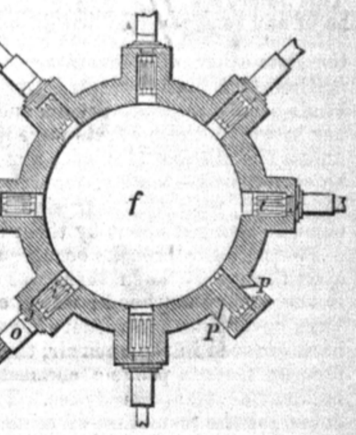


Fig. 2.—Plan

sphere, to supply air to the fire: this object may, however, be effected by making an aperture in the front wall of the fire-place, immediately below the fire-box and grate-bars. *n n*, is the floor or hearth of the kiln. *o o*, are holes, covered up in any suitable manner, but communicating with the ash-pit, and intended to allow of the scoria, cinders, and clinkers being removed. *p p*, in fig. 2, show another manner of supplying air to the fire-places, by making openings in the side walls of the same. *q* represents another mode, by which air is supplied from the atmosphere of the workshop through a grating communicating with the ash-pit. The inventor remarks that, whatever may be the mode adopted for supplying the air to the fire, the same plan should be invariably adopted in all the fire-places of the same kiln.

The patentee, in conclusion, states that he is aware of coal having been used for heating the kilns in which common earthen or delph-ware, and even *tender* English porcelain is commonly baked or fired,—he does not, therefore, intend to claim the employment of pit-coal for such purposes as constituting part of the present improvements; but he claims, First,—the application of coal for heating the kilns or ovens in which hard porcelain is submitted to the baking or firing operation; and, Secondly,—the arrangement or construction of kilns or ovens, as herein shown and described, or any mere modification thereof, whereby pit-coal may be employed as the fuel for heating such kilns or ovens for firing or baking hard porcelain, in the place of wood, which has heretofore been employed for that purpose.

ON GEOLOGICAL CHEMISTRY.

A lecture on " *The Application of Chemical Principles to the Science of Geology.*" By Professor Daubeny.—(Delivered at the Royal Institution, Albemarle-street, March 24th.)

The Professor commenced his lecture with some preliminary observations, in which he said, he had for the last twelve months devoted his leisure to the accumulation and study of facts in relation to volcanic forces; and having, in this pursuit, travelled a good deal along the great boundary line dividing the two kingdoms of geology and chemistry, he had obtained glimpses of truths, which neither the pure chemist, nor the pure geologist might have had the same opportunities of observing—the result being, his entire acquiesence in the opinions of some of the greatest authorities of the present day, that geological inquiries ought, in future, to take more exclusively a chemical direction. The learned professor then proceeded to allude to a subject of geological inquiry, which seemed to him above all others to demand the assistance of the chemist—namely, the metamorphic action which had taken place between certain contiguous but dissimilar rocks—the one of eruptive, the other of sedimentary origin. A large amount of information had been collected by geologists, in respect to different kinds of metamorphic action, and their effects; but as to the manner in which these effects were produced, they would look in vain, unless the chemist also were appealed to. One thing appeared to be established—namely, that the production of mineral veins was connected with the intrusion of plutonic rocks, and with the changes brought about by them in the contiguous strata.

Few metallic deposits occurred in the secondary formations, and even these only when there was dislocation or metamorphic action in their neighbourhood; while, on the other hand, metallic veins were never found in modern lavas, or in volcanic products that had been erupted in the open air, though several geologists had brought forward facts to prove a connection between metallic matter and basaltic or trappean dykes. There were various theories to account for the formation of mineral veins—the first supposed them to be the result of infiltration, the water which percolated the substance of the contiguous rocks carrying with it the several mineral matters they contained, and afterwards depositing them upon the walls of fissures caused by the contraction of the surrounding parts; the second supposed the materials of the vein to have been held in solution by water, but deposited in an insoluble form, owing to slow electro-chemical action; the third hypothesis assumed, that the contents of the vein, being separated from the other materials by sublimation, found their way into fissures, existing either in other parts of it, or in the contiguous formations. No doubt many facts might be alleged in favour of each hypothesis. In the first place, granting that a given rock contained, disseminated through it, any quantity of an oxidisable metal, such as iron, copper, lead, or tin, and that these were already in combination with sulphur, the action of water and air, by generating sulphuric acid, would gradually give rise to soluble sulphates, which might find their way into the contiguous fissures, where, owing to certain electrical or chemical reactions, the metals would be deposited in an insoluble form. Decomposition could be brought about by weak electrical currents; and thus the second hypothesis might be brought in to explain what was left unaccounted for by the first. But both presupposed the existence of metallic matter in the rock from which the veinstone was derived, for it was evident that these several metals could not be present, in the requisite quantity, in strata deposited from water, or all our mineral springs would contain traces of them, just as they did of the silica and other substances supplied by the rock through which they had been percolated. He could not, therefore, help supposing, that the mineral matters, which had been confined to the neighbourhood of plutonic rocks, were, in the first instance, derived by igneous agency, which constituted the machinery by means of which the more uncommon metals were brought originally from the depths to the surface of the earth. It was remarkable, however, that they were not confined to the intrusive rock itself, but, in many instances, were in the metamorphic strata contiguous. There was, also, evidently a connection between the metallic matter in the vein and the character of the enveloping rock, seemingly showing, that the ingredients of the former were not sublimed directly from the interior of the globe, but had been introduced from the formation in contact with the vein. Thus Fournet had stated, that at Andreasburg, in the Hartz, the veins became poorer in metal when they passed from the clay-slate formation into the flinty-slate; and Voltz mentioned a vein in the Vosges which, in traversing successively different varieties of gneiss, had its contents modified in each. Thus, in the first variety, which was charged with mica, the vein was small in its dimensions, and wholly destitute of metal; in the second, which had more of the character of clay-slate, it swelled out to a width of 18 inches, and contained silver, combined with antimony, copper, &c., together with sulphate of barytes; in the third, which contained hornblende, the former were wanting, but the last-mentioned ingredient continued; while, in the fourth, which was wholly destitute of mica, the silver returned for a certain distance down, but was afterwards replaced by selenite, galena, and sulphur, in small quantities. Sir H. de la Beche mentioned similar cases in Cornwall; and the frequency of their appearance compelled the admission, that the materials of the vein were, in many instances at least, dependent upon the character of the rock which it traversed; so that, supposing them derived originally from the same igneous source, a process of segregation had subsequently taken place, by which particular bodies were determined to certain kinds of rock, to the abandonment of others.

In order to pave the way to a solution of these and other difficulties, he submitted two questions—the first, whether igneous rocks did not contain, disseminated through their substance, minute and, probably, infinitesimal quantities of many of those rarer bodies, which were found collected together in mineral veins?—and the second, whether all these substances might not possess a certain amount of volatility, at temperatures below their freezing point, and thus become transported from place to place, at periods long subsequent to that at which they were originally evolved from the interior of the earth, in a state of admixture with other more abundant ingredient? In adopting the affirmative, with reference to the former of these questions, it was not necessary to go so far as to assume, that every basaltic dyke, or even every great volcanic formation, contained, as an integral part, minute quantities of *all* the metals that existed in nature—for, considering how infinitely small was the proportion which they bore to the entire bulk of the crystalline igneous rocks, their absence could not be safely inferred from the fact of their not having been discovered. The facts which inclined him to suspect that they might exist, were the circumstances—first, that the discovery of phosphoric acid, in so large a number of volcanic products, led to the conclusion, that this body, at least, was derived from volcanic emanation, and, by analogy, that metals were also so derived; secondly, the observation made by Henry Rose, that in every crystalline rock traces of copper might be detected by the test of sulphuretted hydrogen—thus suggesting, that if we had any equally delicate test for the other metals, they also might be ascertained to be present; and, thirdly, the fact, that not only iron, arsenic, and selenium, existed amongst the products of Vesuvius, but likewise lead, copper, zinc, and titanium, while tinstone also was ejected by Mount Etna. Now, assuming the existence of metals, and other bodies of rare occurrence, amongst the matters evolved from the interior of the earth by igneous processes, the second hypothesis stated would enable us to account for the diffusion of such matters through the substance of the contiguous strata, as well as for their local accumulation in fissures, or veins; for it was evident, that if these bodies were severally capable of undergoing volatilisation, at temperatures below that of their fusion, the heat, which, originating in the intrusive rock, pervaded the formations contiguous for a great distance around, would drive out portions of all these substances, causing them to become disseminated throughout the latter, and, where fissures existed, to enter in, and contribute to fill them. For this purpose, however, the heat must be long continued, as well as of a certain intensity; and hence, whilst metallic veins were frequent in connection with granite, they were entirely absent from sub-aerial lavas, owing to the more rapidly cooling that would take place in the latter, than where the matter was thrown out under the sea, or at great depths beneath the surface. Thus, according to this theory, the accumulation of metallic matter in veins would have arisen, not from the latter having been the original receptacles of whatever was disengaged from the interior of the globe—for he agreed with Prof. Bischoff, in considering that the idea of metallic, or indeed of any description of veins, being injected in a state of fusion from below, as trap and granite dykes were supposed to be, was encumbered with insuperable difficulties—but owing to the subsequent action of the heat upon the erupted matter, by which the metal might have been slowly volatilised, and thus have found its way into the fissures and cavities contiguous, when the principle of adhesive affinity, described by Prof. Faraday in his "Memoir of the Limits of Evaporation," would come into play; and no sooner was a thin layer of metallic, or other body, collected along the walls of a cavity, than the portions subsequently sublimated would be determined to the same point, until the whole cavity was filled up.

The learned professor also alluded to Tilgman's discovery with regard to the decomposing influence of steam at high temperatures, which accounted for the decomposition of many rocks, and the formation of combinations between the alkalies and fixed acids. Various facts also proved that a certain exaltation of temperature would favour the segregation and new combination of minerals, though that was not essential. To influences of this kind such formations as that of nodules of flint in chalk had been referred, but he thought it more probable that the deposition of silica was the result of the extraction of carbonic acid by the decomposition of animal matter.

He, therefore, suggested the importance of ascertaining by more precise experiments what were the laws which regulated the vaporisation of solids at temperatures below that at which they were fusible. Assuming the truth of this principle, it threw considerable light upon the alterations which contiguous strata underwent from the intrusive rocks—for, the supposing a certain degree of mobility to be produced by heat, without actual fusion, would enable us to understand these changes. The learned lecturer then proceeded to discuss the difficult question of dolomisation, which he contended might be solved by a reference to the same principles, aided by analogous facts known to chemists, with respect to carbon and other substances. The whole question, however, appeared to be open to further inquiry, both as to the degree of volatility possessed by magnesia and its several combinations, its power of penetrating the substance of a calcareous rock, and combining with its ingredients in atomic proportions—neither body being in a state of absolute fluidity—its transmissibility to great distances through an intervening mass of rock, and the circumstances which caused it to accumulate in certain sets of beds, and to pass over others. Experiments should, likewise, be made as to the changes which augitic rocks sustain under the influence of a high temperature, and as to the possible disengagement from them of magnesia under the circumstances supposed; nor was chemical research less called into request, for the purpose of enabling us to explain such phenomena as were produced by igneous causes at the present day, than for the elucidation of processes of higher antiquity. When he reflected upon the assemblage of chemical phenomena which presented themselves during the several phases of volcanic action—the enormous and long-continued evolution of carbonic acid—the inexhaustible supplies of sulphur, arising from deposits, originally caused by the decomposition of sulphuretted hydrogen—the volumes of steam and muriatic acid disengaged by those volcanoes which were in a state of activity—the sublimations of common salt, sal-ammoniac, &c., which generally accompanied an eruption—the nitrogen gas evolved incessantly for centuries from many thermal springs—when he saw these, and other results of internal chemical action, come so prominently into view in every part of the world where opportunities for studying the operations of internal heat were presented, it did excite his surprise that philosophers of high name should have rested content with a theory which professed to ascribe everything to the mere protrusion of some of the fluid contents of the globe through parts of its crust, without regarding features so important, and apparently so essential, as those to which he had alluded.

He thought that much was to be learned with respect to volcanoes, by minute chemical examinations of the solid products ejected, with a view of comparing their constitution one with another, and of the gases and vapours evolved before, at the time, and subsequently to, a volcanic crisis. The learned lecturer then referred to Prof. Abich's experiments with regard to felspar and to the recent discoveries at Vesuvius, representing the evolution of hydrogen from an active crater, and to the results which might be expected from further discoveries. In the meantime, even with our imperfect knowledge of these mysterious workings, we might obtain glimpses of a beautiful system of compensation—of an adaptation of means to an end—which struck the observer all the more, when it was displayed, as in this case, in the midst of those terrible manifestations of irresistible force, which the workings of a volcanoe, or an earthquake, revealed. This was shown by the useful purposes performed on the surface of the globe by the carbonic acid evolved from its interior, and was also illustrated by the occurrence of metals in veins, and the diffusion of phosphates in minute quantities so generally through the strata. Had not this been the case, the former would not have become known to us, and the latter would not have been available for the nutrition of plants.

Such were a few of the facts to which he had been desirous of directing attention, by way of inducement to his auditory to pursue the science of geology with a frequent reference to chemical principles; and he wished to impress upon those just entering upon the study more particularly, the great truth, that in all kinds of research, chemistry was to be regarded as the grammar to the language of Nature—the key to unlock her most secret mysteries; and that those who were ambitious of following in the footsteps of the great men who had adorned, and still adorn, that noble Institution, by fathoming the depths of some one of those sciences which were there cultivated—nay, even those who, with humbler aspirations, were content, like himself, to snatch a mere superficial glance of several—would ever find it impossible to proceed without its assistance. His own experience justified him in assuring his auditory, that whether their chief interest might chance to lie in physiology—vegetable or animal; in scientific husbandry; or in those cosmical phenomena which presented themselves to the explorer of mountainous regions—chemistry would suggest at once the right principles for interpreting the facts observed, as well as the soundest practical application that admitted of being deduced from them.

THE TIDES OF THE IRISH AND ENGLISH CHANNELS.

Report of Experiments made on the Tides in the Irish Sea; on the similarity of the Tidal Phenomena of the Irish and English Channels; and on the Importance of extending the Experiments round the Land's End and up the English Channel. By Captain F. W. Beechey, R.N.—(Read at the Royal Society, March 9 and 16, 1848).

The author commences by stating, that the set of the tides in the Irish Sea had always been misunderstood, owing to the disposition to associate the turn of the stream with the rise and fall of the water on the shore. This misapprehension, in a channel varying so much in its times of high water, could not fail to produce much mischief; and to this cause may be ascribed, in all probability, a large proportion of the wrecks in Carnarvon Bay. The present inquiry has dispelled these errors, and furnished science with new facts. It has shown that, notwithstanding the variety of times of high water, the turn of the stream throughout the north and south channels occurs at the same hour, and that this time happens to coincide with the times of high and low water at Morecombe Bay,—a place remarkable as being the spot where the streams coming round the opposite extremities of Ireland finally unite. These experiments, taken in connection with those of the Ordnance made at the suggestion of Professor Airy, show that there are two spots in the Irish Sea, in one of which the stream runs with considerable rapidity without there being any rise or fall of the water, and in the other the water rises and falls without having any perceptible stream; and the same stream makes high and low water in different parts of the channel at the same time; and that during certain portions of the tide, the stream, opposing the wave, runs up an ascent of one foot in three miles with a velocity of three miles an hour.

The author enters minutely into the course of the stream, shows that the point of union of the streams from the opposite channels takes place on a line drawn from Carlingford through Peel in the Isle of Man on to Morecombe Bay; and concludes his remarks on this part of the subject by adverting to the great benefit navigation will derive from the present inquiry. He then notices a chart of lines of equal range of tide, which has been compiled partly from the ranges published by the Royal Society, and partly from observations made on the present occasion; and has annexed a table by the aid of which the seaman will be able to compare his soundings taken *at any time of the tide* with the depths marked upon the Admiralty charts. Next follows the mention of a feature in the motion of the tide-wave, which Capt. Beechey thinks has hitherto escaped observation; viz. that the upper portions of the water fall quicker than the lower,—or in other words, that the half-tide level does not coincide with the place of the water at the half-tide interval; that this difference in the Bristol Channel amounts to as much as four feet, and that the law seems to be applicable to all the tides of the Irish Sea.

We are next presented with a table exhibiting the various curves assumed by the tide-wave, and with the durations of the ebb and flood at each place. Having explained these observations in the Irish Sea, the author proceeds to apply to the tides of the English Channel the law which he found to regulate the stream of the Irish Channel,—availing himself of the observations of Captain M. White and others for this purpose. There was no difficulty in adapting the rule in the upper part of the channel; but below the contraction of the strait, the apparent discordance was so great that nothing but a reliance on the general accuracy of the observations prevented the inquiry being abandoned. It seemed that the streams are operated upon by two great forces, acting in opposition to each other; viz. that there is a great offing stream setting along the western side of the British Isles, and flowing in opposition to the tides of the channel above the contraction, turning the stream with greater or less effect as the site is near to, or removed from, the points of influence. By pursuing this idea, it was seen that the observations in the English Channel respond to it; and then applying it to the offing of the Irish Sea, and considering that channel to comprise within its limits the Bristol Channel, as the English Channel does the Gulf of St. Malo, it was found that the observations there also fully bear out the idea. So that there was afterwards but little difficulty in tracing the course of the water, and bringing into order what before appeared to be all confusion. The author then traces the great similarity of tidal phenomena of the two channels, and proceeds to describe them. For this purpose he considers the Irish Channel as extending from a line connecting the Land's End with Cape Clear to the end of its tidal stream, or virtual head of the tide at Peel; and the English Channel from a line joining the Land's End and Ushant, to the end of its tidal stream off Dungeness.

With these preliminary lines, he shows that both channels receive their tides from the Atlantic, and that they each flow up until met by counter streams; that from the outer limit of the English Channel to the virtual head of its tide the distance is 262 geographical miles—and in the Irish Channel, from its entrance to the virtual head of its tide, it is 265 miles. In both channels there is a contraction about midway; by Cape La Hogue in the one, and by St. David's Head in the other, and at nearly the same distance from the entrance. In both cases this contraction is the commencement of the regular stream, the time of the movement of which is regulated by the vertical movement of the water at the virtual head of the channel; situated in both cases 145 miles above the contraction, and that the actual time of this change, or Vulgar Establishment, is the same in both cases. Below the contraction of the strait, in both cases the stream varies its direction according to the preponderance of force exerted over it by the offing stream. In both cases, between the contraction and the southern horn of the channel there is a deep estuary (the Bristol Channel and the Gulf of St. Malo) in which the times of high water are nearly the same, and where, in both, the streams, meeting in the channel, pour their waters into these gulfs, and in both raise the tide to the extraordinary elevation of forty-seven feet. From the Land's End to the meeting of these streams in one case is seventy-five miles, and in the other the same.

In one channel, at Courtown, a little way above the contraction, and at 150 miles from the entrance, there is little or no rise of the water; and in the other, about Swanage, at the same distance from the entrance, there is but a small rise of tide also (five feet at springs). In both cases these spots are the node or hinge of the tide-wave, on either side of which the times of high water are reversed. And again, near the virtual head of the tide, in both cases, there is an increased elevation of the water on the south-east side of the channel of about one-third of the column—the rise at Liverpool being thirty-one feet, and at Cayeux thirty-four feet.

The author traces a further identity in the progress of the tide-wave along the sides of both channels *opposite to that of the* node. In the first part of the channel the wave in each travels at about fifty miles per hour; in the next, just above the node, this rate is brought down to about thirty miles in one, and to sixteen miles in the other; it then in both becomes accelerated, and attains to about seventy-six miles per hour. Lastly, the author observes that the node or hinge of the tide, placed by Prof. Whewell (in his papers on the tides) in the North Sea, is situated at the same distance nearly from the head of the tide off Dungeness, as the node near Swanage is on the opposite side of it; and that in the Irish Channel, at the same distance nearly as the node at Courtown is from the head of the tide off Peel, there is a similar spot of no rise recently observed by Capt. Robinson. Capt. Beechey's letter was illustrated by charts and diagrams, showing the identity and singular phenomena of these two great channels.

MR. HAY'S THEORY ON SYMMETRICAL BEAUTY.

On the Production of the Beautiful—an attempt to prove that the Theory advocated in the Papers read by Mr. D. R. Hay *before the Society, founded on the development of the Harmonic Ratios, is fallacious.* By Mr. Thomas Purdie.—(Read at the Royal Scottish Society of Arts, March 13 and 27).

Part I.

Mr. **Purdie** commenced his paper by referring to the opinions of those philosophers of the Socratic school whose names had been used in support of the theory under consideration. He endeavoured to show, by quotations from Lord Jeffrey's "Essay on Beauty," and from Dr. Reid's works, that these opinions were hostile to all theories of such a nature. He next adverted to Vitruvius, and stated that he propounded a theory of a similar character to that whose fallacy he had undertaken to prove. One of the diagrams used by Vitruvius in applying his principles to practice was exhibited; the same diagram being used by the author of this theory in explaining the harmonies of the Parthenon. He stated, however, that Vitruvius could not be considered as an authority in regard to the principles on which styles are founded, having been led away by his fondness for metaphysical distinction and refinement, to refer them to sources with which they had no connection. This statement was supported by quotations from the works of Vitruvius himself, from Lord Aberdeen's "Principles of the Beauty of Grecian Architecture," and from the article *Architecture* in the "Encyclopædia Britannica."

As the second division of his subject, Mr. Purdie referred to the labours of Kepler in proving the harmonies and analogies he supposed to exist throughout nature—to prove which, great part of his "Mysterium Cosmographicum" and "Harmonices Mundi" were written. He investigated the reason of the Zodiac being divided into 360 degrees. It led him into some subtle considerations in relation to the divisions of the musical scale. Mr. Hay investigates the properties of the number 360, and his investigation seems to lead to a conclusion of a similar nature.—(See p. 24 of his book on Symmetrical Beauty). A quotation was read from one of Galileo's Dialogues, denouncing the belief prevalent in his time as to the beauty supposed to reside in the harmonic ratios, that being the principle on which the present theory is founded. He quoted a passage from Bacon, tending to show that he considered the ideal beauty of the Greeks, and that formed by geometrical proportion, to be antagonistic. In it Bacon contrasts Albert Durer, "who would make a figure by geometrical proportions," with Apelles, "who would choose the best parts out of diverse faces to make one excellent."—Numerous quotations were given from various authors, as to the universal prevalence, in the 15th century, of the "dangerous ideas of the aptitude and congruence of numbers," and of the absurdities to which the style of reasoning from analogy lead. By this, Francesco Sizzi attempted to disprove the existence of Jupiter's satellites. A celebrated musician held that God created the world in six days, and rested the seventh, because there are but seven notes in music; and Kepler, by a similar process, explained the music of the spheres, in which Saturn and Jupiter were proved to take the bass, Mars the tenor, the Earth and Venus the counter-tenor, and Mercury the treble.

As the third division of the subject, Mr. Purdie gave a short account of the theory advanced by Alison, advocated by Lord Jeffrey and others, and generally recognised by modern metaphysicians. He did not feel himself qualified to enter on the differences existing between Alison, Lord Jeffrey, Payne Knight, and Dugald Stewart. They appeared to be as much of a philological as a metaphysical nature, and did not affect his branch of the subject. He had not had time to make himself acquainted with Sir George M'Kenzie's refutation of Alison, and could not say what effect it might have had in modifying his opinions on the subject. In the meantime, although he could not say this theory accounted satisfactorily for every phenomenon connected with beauty of form, it seemed to him to account for far more of them than any other he had yet met with.

As the fourth branch of the subject, he stated the nature of the theory under consideration, and attempted to show the fallacies contained in it, and in all others of a similar nature which attributed beauty to proportion. The grand principle of this theory—that by which it must stand or fall—appeared to be (p. 66, Symmetrical Beauty), that there exists in the human mind "an universal inherent mathematical principle of harmony which gives a response to every development of its laws, whether in sound, form, or colours." He devoted some time to the consideration of this faculty. His arguments went to prove, that if such a faculty existed, it could be nothing else than what is commonly called instinct. To combat this idea, he quoted a motto from Mr. Hay's publication on Form, itself a quotation from Burke:—"Wherever the best taste differs from the worst, I am convinced that the *understanding* operates, and nothing else." He argued, if the faculty by which we distinguish the musical intervals be that by which we become sensible of the beauty of form, the result is inevitable,—that all animals, such as the mocking bird, which can distinguish these intervals and follow them, must be conscious of the beauty of form also. He stated that the only proof advanced in favour of this theory was drawn from analogy, because we find the harmonic ratios are necessary to the primary beauty of a musical chord. These ratios have been applied to form, as being necessary to constitute its beauty also. He argued, if we are to conclude that these ratios are necessary to constitute the beauty of form, simply because we find they are so to the primary beauty of a musical chord, we must, on the same grounds, conclude they are necessary to the objects of the other senses; but that this would involve the absurdity of attempting to account, on mathematical principles, for the same man partaking with equal relish of things sour and sweet, salt and fresh,—eating pickles to his animal food one day, and currant jelly the next; for an European lady preferring the scent of aromatic vinegar to asafœtida, while some tribes of savages infinitely prefer the latter. He spoke at some length on what he conceived to be the unphilosophical nature of such a mode of establishing a theory. What is true in regard to a theory founded on the science of acoustics, may be, and is indeed likely to be, utterly false when applied to and founded on the laws of perspective. A sound always reaches the ear precisely of the same pitch as it left the sounding body, while a form makes a different impression on the eye with every change of position. Thus, supposing the beauty of the Parthenon to depend, as asserted by the theory under consideration, on the harmony of the diagonals drawn within the various rectangles which can be described within the building, it could not in reality be beautiful at all, as there is no point from which all these diagonals could possibly be presented to the eye in their true position. Even standing immediately in front of the building, the diagonals drawn in the rectangles between the nearest columns would necessarily present to the retina a much more acute angle with their base line than those farther removed. Take one step to the right hand or the left, and the angle of 75 becomes one of 76 or 77, and so changing with every step until the columns are seen close together, and every one of these angles becomes a straight line.

Mr. Purdie followed this with some remarks tending to prove the fallacy of all theories which assume proportion as their basis. How could any such a theory account for the beauty we discover in a human figure and in a horse? Yet the principle must be the same, by our recognising beauty in styles of architecture so various that some of them seem to be beautiful from the want of qualities which some of the others possess—as the Moorish, the Grecian, the various kinds of Gothic, and Elizabethan; none of them having a single feature in common, either in their proportions or their details. That these differences are not confined to the different orders, but exist in various examples of the same order,—a drawing was exhibited of four specimens of Corinthian: from the Choragic monument in Athens—the temples of Jupiter Stator and Tonans, in Rome—and of Vesta at Tivoli; all exceedingly beautiful specimens of the order, but without a single feature in common, either in their proportions or details. He adverted to the universal agreement as to the fundamental principles of harmony in music, and the proverbial differences on the most fundamental points as to beauty of form—to our recognising beauty in the figure and dress of a modern belle, and our considering it an outrage on taste to transfer the same costume to marble, although the same form and face be preserved. The origin of our feelings, he said, is here too obvious to escape notice. A statue lives a thousand years, a man threescore. Our taste for sculpture has been modelled on that of antiquity, and cannot now change. Our dresses last not a lifetime, but must be changed as necessity requires. Makers of them will exercise their skill and ingenuity in devising new forms—hence change of fashion; and hence our ideas also change, and attach themselves to those forms with which we are in the habit of associating all that is graceful and elegant. A modern statue, even in a modern costume, would, in ten years, address us in antiquated language, without having the respect due to antiquity. The Grecian statues speak to us in a dead language which changes not, and they speak to us of hoar antiquity—of the knowledge, the skill, the taste, and the cultivation to which that wonderful people had attained, and from whom they are descended to us.

Mr. Purdie concluded his paper by characterising all attempts to establish a theory on such grounds as this, in the words of Lord Jeffrey, as "dogmatising from a few examples, instead of defining any general comprehensive principle, in which all beauty may be supposed essentially to consist.' An attempt, he continued, as reasonable, and of precisely the same nature, as that of a man who, setting out with the premises that every oak tree is a vegetable, attempts therefrom to prove that every vegetable must be an oak tree.

Mr. Purdie then intimated that he would be prepared, in the second part of his paper, to go somewhat more into detail, and to prove the fallacy of the theory from its own inherent defects and self-contradictions; for of these he conceived it contained sufficient for the purpose, although he might have failed in convincing any one on the general question.

PART II.

Mr. PURDIE commenced the second part of his paper by recapitulating shortly the contents of the first. He then proceeded to explain the scope of the theory he had undertaken to refute. It was intended to be applied to universal nature. This was sufficiently shown by the "universal mathematical principle of harmony" assumed to be "inherent in the mind," for the purpose of giving a response to the laws of the theory. It followed that no object could be beautiful in which those principles were not developed. He quoted two passages from Mr. Hay's book on Symmetrical Beauty as still farther explaining this, and showing *how* these laws are extended to universal nature.—"In these" (the organic forms of nature) "the first principles of symmetrical beauty are so blended with the picturesque, and operate in a manner so exquisitely refined and subtile, that mankind have as yet been unable to systematize them."—p. 2. "In compositions of high art, the principles of symmetrical beauty are so subtilely imparted as not to exhibit themselves."—p. 4. To these he requested particular attention, this being the point at which all such theories fail, *i. e.* in the attempt to account for beauty of dissimilar or of opposite descriptions,—such, for example, as that which we discover in a child and in a full-grown man—in a horse, a Newfoundland dog, or a greyhound; or a building—Doric, Ionic, Corinthian, Elizabethan, or Gothic. He said this was a mere begging of the question, a counterpart of Alexander the Great's mode of *unloosing* the Gordian knot. It would make the principles of this theory to be somewhat like the music of the spheres—filling heaven and earth with their strains—strains so "*exquisitely refined and subtile*," as to be altogether imperceptible to moral ears. Would not the natural conclusion rather be—"*De non apparentibus et non existentibus eadem est ratio?*" It was admitted these principles of symmetrical beauty did not show themselves in works of high art. The admission was correct. They did not show themselves—only because they did not exist. Mr. Purdie next referred to the Parthenon, whose proportions it was attempted to show were in accordance with the principles of the theory. In making the attempt, however, it was admitted that several "*discords*" existed—the outer intercolumniations being closer than the others. It is attempted to get rid of this difficulty by saying that the outer intercolumniations are relieved against the sky, while the others are seen against the body of the building—that an open space between two columns, seen against the sky, appears wider than when seen against a background in shade; and this assists in harmonising them.

Mr. Purdie then showed, from the ground plan of the building, that there is visible a space of only two feet through the outer intercolumniation, while nearly four feet can be seen through that next it. This, therefore, instead of assisting the theory out of its dilemma, only increased the difficulty. Besides, a glance at the ground plan would have shown that the same intercolumniation was applied to the inner row of columns, which were so close to the building, they could never be seen against the sky at all. He then explained the reason usually assigned for the nature of the intercolumniation used in Grecian Doric, which is connected with the arrangement of the triglyphs and metopæ. He said, Mr. Hay stated that the line of the tympanum formed with its base an angle of 15 deg.; that "as the angles of the pediment in Plates 6, 7, and 15 (of Stuart's Athens) all differ," he "adopted that of the latter, as being the most likely to be correct, because the pediment is there given by itself."—(Symmetrical Beauty, p. 72). Mr. Purdie showed, by reference to the text of Stuart's Athens, that Plate 15 did not refer to the dimensions of the pediment at all, but was only intended to convey an idea of the sculpture, and was given without measurements. The measurements were correctly given on the elevation,—although the elevation itself was not in accordance with them. By a calculation made from these measurements it would be found to form an angle of 13 deg. 24 min. There was a statement in the text, noticing the inaccuracy of the elevation. The real angle was there stated to be 14 deg. If the rest of the angles given had been taken from the elevation by means of the protractor, as they appeared to have been, they must be all wrong together, as the tympanum, as there represented, is 18 inches too low.

This was the second attempt made to set the Parthenon to music. The first was proved and acknowledged to be a failure. Of that attempt the *Athenæum* remarked, June 10, 1843—"It is easy to see that a general notion of this kind is a most insufficient basis even for a plausible theory. * * Mr. Hay is wrong when he asserts that certain proportions are beautiful *because* they are those of the notes which, in all the combinations of harmony and melody of sounds, are most pleasing. His proportions as assigned to form are most correct and most beautiful. They are not, however, those of the beautiful sounds to which he assigns them."

The Grecian Doric, therefore, was not in accordance with the principles of this theory. Perhaps the attempt might be more successful when tried with the other orders; but if it failed with the Doric, the proportions of which were comparatively invariable, the Ionic and Corinthian must be still more perplexing, the latter of which varied so much that the writer of the article *Architecture*, in the "Encyclopædia Britannica." said it was scarcely possible to give any general description of it. If it failed with any of these, there would remain for it but a small chance of success with the Gothic or the Elizabethan.

Mr. Purdie said, it might save the introduction of much irrelevant matter, if it were kept distinctly in recollection that he was not attempting to refute some imaginary theory which might be brought forward in the course of the discussion, but that advocated before the Society by Mr. Hay, and contained in his published works. That theory was founded on the harmonic ratios. No doubt, order, proportion, and harmony were all necessary to the beauty of architecture; but it was not by the harmonic ratios these were to be obtained. The "Greek architects allowed themselves to be fettered in their general proportions only." This theory did not establish general proportions at all. In music, the application of harmonic ratios, while they allowed all latitude as to general proportion, limited beauty to certain fixed points or coincidences, from which when the slightest departure was made, discord ensued. Thus a difference of a semitone would make as disagreeable a discord as a full tone, and one quite as easily recognised. It mattered not whether too high or too low. The application of the harmonic ratios to forms was intended to produce a similar effect. Thus in the case of a well-proportioned column, six inches added to its height would be as easily observed as 18, and quite as destructive of its beauty; and were the height diminished by 18 inches instead of being increased, it ought to be no more so, the departure from the harmonic ratio in either direction being equally discordant. The instant the correct proportions were departed from, deformity would be the result; but let the alteration be continued a little farther in the same direction, the deformity would be got rid of—a new chord struck, and beauty and symmetrical proportion again obtained.

Mr. Purdie stated shortly what he conceived to be the source of the beauty of architecture and sculpture, and referred, as the best sources of information with which he was acquainted, to Lord Aberdeen's inquiry into the principles of beauty in Grecian architecture—Gwilt's Preface to Chambers's Works—the Essays of Alison and Lord Jeffrey, and the lives of Christopher Wren and Michael Angelo Buonarotti, published by the Society for the Diffusion of Useful Knowledge. It was not necessary to seek for any mysterious geometrical law. The taste of a nation, and their power of producing and appreciating beauty, depended on their progress in civilisation, on education, and the refinement these naturally produce. "The beauty and perfection of the school of Phidias accompanied the great moral and intellectual improvement of the times, and art was most perfect when Æschylus, Sophocles, and Euripides, produced their tragic poems; and Socrates and Plato, and the great Grecian statesmen, by their writings and example, improved the moral and political state of mankind."—(Life of Michael Angelo.) That this tended to prove the general correctness of Lord Jeffrey's definition of taste—"That the power or faculty of taste is nothing more than the habit of tracing those associations by which almost all objects may be connected with interesting emotions."

Mr. Purdie then took notice of some of the methods given for applying the theory to practice, and contended it was equally potent to produce the ugly or the beautiful. According to the method given by Mr. Hay for drawing the human countenance, an oval was first described, and within it a triangle, its apex undermost. At the apex the mouth was placed, and the eyes at the two upper angles. But no rule was given for placing the apex of the triangle undermost. One might, if he felt so disposed, reverse both the triangle and oval; it might be some bungling Grecian sculptor who thus reversing his triangle, invented the Cyclopean type, with one large eye in the centre of the forehead, and a mouth extending from ear to ear at its base.

A similar effect would take place with the profile, in drawing which an oval is given for the face and a circle for the back of the head. He said the profile is not an oval, nor is the back of the head a circle. To render the back of the head a circle, a large slice must be taken from "self-esteem;" and "philoprogenitiveness" would suffer an amount of reduction which might seriously interfere with the increase of the population. The back of the head was, strictly speaking, no more a circle than a square; and if it were a square, or a rectangle, provided always it were a harmonic one, its consistency with the principles of the theory might have been quite as easily manifested.

Mr Purdie then proceeded to consider what are styled (p. 31, Symmetrical Beauty) a series of peculiarly symmetrical rectangles, which are evolved by using the diagonal of the square as the base of the first, the diagonal of the first as the base of the second, and so on. Mr. Hay, however, did not adopt these as they naturally arise. They did not accord with the harmonic ratios, and were altered to suit.

Mr. Purdie pointed out on a diagram the amount of the alteration. He said Mr. Hay referred to the temperament used in music in its justification. Mr. Purdie explained the nature of musical temperament, and showed there was no analogy between it and the process adopted with these rectangles. He stated the temperament in music was a modern invention, and seemed somewhat out of place in a treatise which claimed support as elucidating the principles of the ancient Greeks. Were such a principle as this tempering admitted into science, it would be easy to obtain any results. Such an arbitrary alteration of a series of figures in a science claiming mathematical accuracy, would have been conclusive against it, had it been in other respects unassailable.

Mr Purdie next referred to the egg oval, and Mr. Hay's method of producing it, which might be new to many of the members, and was (leaving out the harmonic ratios) the simplest and best method. He said, whatever merit its application to the drawing of vases might possess, it had not that of novelty to recommend it, but had long been familiar to every one who had given any attention to the subject. He exhibited in Nicholson's "Architectural Dictionary" several good examples of vases so constructed, along with a variety of methods of producing the figures on which they were based.

Mr. Purdie explained the effect of engrafting the harmonic ratios on them, and exhibited a variety of diagrams to test whether any one could point out the discordant from the harmonic. But the method adopted in forming these ovals was, he contended, altogether subversive of the theory.

Four pins are put in at certain fixed points, and a string tied round them, for the purpose of obtaining the form of two harmonic triangles; but, before proceeding to produce the oval, one of the pins is pulled out. For this no reason could be assigned but the will of the operator. It did away at once with all idea of harmonic relation. A figure so constructed could bear no mathematical relation to the triangles on which it was based. Extend the radii to infinity, and a circle would be obtained independent of the shape of the triangles: reduce the string to a sufficient tension, and it would become a triangle. A figure so constructed vibrates between the circle and triangle. At no possible point between the two could it bear any harmonic relation to the triangle on which it is based.

In conclusion, Mr. Purdie said, that the origin of the fallacies contained in this theory appeared to be an extravagant fondness for analogy, through which the idea had been conceived of engrafting the principles of music on form: that, instead of analysing the phenomena of mind, and deducing the principles of a science from the facts so ascertained, the mental phenomena had been left out of view altogether, and the theory formed on a mathematical basis depending on the harmonic ratios: and that the result was a theory utterly at variance with those very phenomena on which it ought to have been founded. The only method of investigating the truth in metaphysical science was by inductive philosophy, the slightest attention to the principles of which would have saved the author of this theory from the manifold blunders into which he had fallen.

After the reading of the above paper, Mr. Hay made some remarks "*On the effects of Perspective upon Proportion, being the first of a series of short papers upon the Harmony of Form.*"

Mr. Hay commenced by apologising to the members of the Society generally, for calling their attention to a fact, with which he believed they were familiar. But that fact had been denied at the previous meeting, in an attempt to prove a fallacy in his system of applying the numerical harmonic ratios to the proportioning of rectangular forms; and its denial seemed to be well received by the younger members. Mr. H. therefore, felt called upon to state the fact, and to demonstrate it. The fact, he stated was "that whatever system of proportion may be applied in arranging the parts in the geometric elevation of a building, will also operate upon the effect of that building, in whatever degree of obliquity it may be viewed." He exhibited five drawings, two of which fully explained his system of applying the numerical harmonic ratios, and the other three demonstrated the fact which had been denied at the previous meeting; and therefore concluded that the attempt to prove the fallacy of the system, by the denial of this fact, had failed.

Mr. Hay observed, that an attempt had also been made, at the previous meeting, to assimilate his system of the application of numbers to symmetrical beauty, with the mystical application of particular numbers by the alchymists, and some of the philosophers of the middle ages; and offered to prove that this attempt was also a failure, inasmuch as he employed numbers in an intelligible, not a mystical manner.

PECULIARITIES IN THE CONSTRUCTION OF GREEK ARCHITECTURE.

Abstract of a paper "*On the Geometrical Lines and Optical Corrections of the Greek Architects.*" By F. C. Penrose, Esq.—(Read at the Royal Institute of British Architects, February 21st.)

I will observe, that although the scrupulous accuracy with which the measurements which I shall produce have been recorded may seem almost absurd to some, it will not appear so to those who have been so fortunate as to see the originals, and observe the perfection of the workmanship with which they are put together, and the exceedingly happy preservation of many parts from the weather, which enables measurements to be taken with precision in these, where in many buildings they could only be a matter of approximation.

I use as my standard of measurement the English foot, and divide it into 100 parts which I shall call cents.

In the beginning of the year 1846 I was at Athens. I had an introduction to M. Riedel, a Bavarian architect, who accompanied me on my first visit to the Acropolis, and pointed out to me the peculiarities of construction of which I am about to speak; it was the first time I had any intimation that there was any departure from ordinary line and rule work in these buildings, excepting a rumour which I heard from our consul at Trieste, that there was something very curious recently discovered in the ancient buildings at Athens.

These peculiarities, which were then pointed out to me, were the convexity of the stylobate on the four sides of the building, and the inclination of the columns towards the centre of the building; that is to say, on the east front the axes of the columns incline in a westerly direction, and those of the west front easterly. Those on the north and south flanks, south and north respectively. It follows that the angle columns share the two inclinations; for instance, the north-east angle column inclines in a direction south-west.

This fact has been ascertained some time; it is given with considerable accuracy in that part of the supplement to Stuart which was supplied by Mr. Jenkins. The exact amount, owing to the slight displacements which the building has suffered, is only to be obtained by a diligent survey of the whole building.

The observation of the convexity of the lines of the steps is more recent. I believe that one of our countrymen, Mr. John Pennythorne, was the first who paid any discriminating attention to these lines. I use this phrase as they cannot but have in some measure influenced our earliest investigation, as no one could ever have cast his eye along any portion of the upper members without being sensible of them. The lower lines of the building were, as I understand, quite encumbered with rubbish until the excavations of the last few years. Any measures obtained by boring must have been vitiated, and they have doubtless given many a diligent measurer a vast deal of trouble, and many have been the dimensions which have stood at dismal variance with themselves, and been cast aside without being really to blame.

Mr. Pennythorne was the first to see in these an original intention and meaning; he however kept his knowledge to himself, and the world first heard of it through the communication of MM. Hofer and Schawbert, German architects, to the *Bauzeitung*, in the year 1838.

I was very much struck, as all who have seen the Greek buildings must be, by the perfection of the workmanship, and I took such levels and dimensions as I could with the instruments I had with me, for the purpose of ascertaining the amount and nature of these adjustments. And I arrived at a sufficient degree of exactness to assure myself that it was well worth while to go deeper into the matter. I, however, (in 1846), was not able to pursue the subject any further, and I returned to England in the autumn of that year, and had the pleasure of reading a paper to this Institute on the observations.

They attracted more sensation than I had any right to expect, and I received a proposal from the Society of Dilettanti, that if I were willing to go out to Athens, for the purpose of taking more accurate observations, they would assist my operations with a sum of money. This proposal I willingly accepted, and provided myself with the necessary implements, and induced a young architect (son of Mr. E. Wilson, of Lincoln, the well-know archæologist) to accompany me, and we arrived at Athens towards the end of October last year. I was also so fortunate as to fall in company with Mr. Meyer, associate.

The first thing which we attempted was the measurement of the base line, namely, the length and breadth of the building. This was done with steel tubular measures, compared at the time of measurement with the thermometer, from which also long deal rods were graduated for the measurement of the heights, and for general purposes. The steel rods were carefully compared by Mr. Simms, both before and after my return, with his standard, and I gave the results as delivered at Athens. They are still subject to a very minute correction, but not worth troubling you with at present.

As soon as the weather allowed, and the requisite permission obtained from the local authorities, I proceeded to hoist a scaffolding at the east-end, of which I made an entire circuit, beginning with the three columns which are standing on the north side, and ending with the south-east angle column.

In this examination we plumbed every column, measured every stone of the architrave, the capital, and upper and lower stones of each column, in every direction; took careful measurements of all the cracks which have in any way modified the original form, and obtained levels of all the lines of the entablature at fixed points; and finally examined the entasis of five different columns, taking several sections of each.

We then migrated to the west-end, where I contented myself with making an exact examination only of the two angular columns, which position enabled me to obtain the levels of the upper members of the western part. I also took all such measurements in the western parts as my examination of the eastern part had pointed out to me as necessary to arrive at the exact original state. I then proceeded to examine the upper members of the posticum, and the arrangement of the tympanum, which has some peculiarities worth notice connected with the support of the statues. Then the roofing, the ceiling, and lastly, the original painting, engaged our attention.

This work in the upper part of the building was naturally very much exposed to wind, &c. It often happened that while it was impossible to do any accurate work on the scaffolding, we might be employed profitably below. But frequently it was altogether out of the question to go up to the Acropolis at all. The pavement was of course levelled in every part and several times over, until the whole system worked perfectly together, and I could satisfy myself that I had got the exact curve in every instance, or at least within one or two thousandths. We also took such measures as sufficed for the accurate position and proportions of the cella, with the arrangement of columns within it. This sums up our proceedings at the Parthenon, which occupied nearly five months. The Propylæa occupied a considerable share of attention, and I searched the temple of Theseus to find how far it was analogous to the Parthenon.

Last, but not least, we ascended the temple of Jupiter Olympus, from which we obtained various measurements and drawings.

The measurements of the breadth of the temple on the upper step, at the east and west ends, I found to be respectively 101·341 and 101·361,—north and south, 228·141 and 228·154 respectively. This exceedingly small difference in measures which were certainly intended to be equal, points out the limit of error, which can be attributed solely to inaccuracy of measurement in other dimensions, namely, about 1 in 5,000. I may just observe that I found my wooden measures, notwithstanding they had been previously saturated in oil, subject to a fluctuation in various states of the atmosphere rather greater than this amount. So that, had the eastern front of the Parthenon been set out with deal rods on a dry day, and the western on a moist day, we should have had as great a difference between them as actually exists.

It follows that all quantities which tend to proportionality must be looked at with great suspicion, in which varieties exist sensibly greater than this small admissible error.

The breadth of the temple of Theseus is 45·011, and its length is 104·23. The former is almost exactly in proportion of $\frac{4}{9}$ths of the breadth of the Parthenon: this, I think, was intended.

But a difficulty occurs if we attempt to proportion the front with the flank on the upper step. It has been suggested to try the equilateral triangle. That, however, notwithstanding its being near enough the mark to suggest the trial, leaves the quantity = ·282 unaccounted for at the end; and, besides, I do not find that in the Parthenon there are any affinities whatever to that figure.

I very much prefer to descend from the upper step, and try the proportions on the second. By this addition, the flank becomes 106·63, and the front 47·41.

We now obtain a proportion 9 to 4, differing from exactitude by so small a quantity as to be fairly admissible.

It is somewhat remarkable that the quantity 1·066 is found frequently in the measures of the Erectheum.

The proportion of solids to voids is 4522 to 1000, nearly as 9 to 2.

I have now stated the principal larger proportions: I will state a few others, which are the more important secondary ones. A very happy artifice is the walls of the pronaos and posticum being thicker than the cella walls.

The height of the columns of the Parthenon is exactly $\frac{15}{100}$ length of temple on upper step, the breadth of the abacus of six of the eastern columns is exactly $\frac{1}{13}$ breadth of temple; they are not all equal, but I have given the dimensions of those at the eastern end, which always gives the key to the main proportions.

In the temple of Theseus, the column is exactly $\frac{18}{100}$th of length of temple on the lower step, and the abacus $\frac{1}{12}$th of the breadth on the upper step. In both, this member appears to be the unit of measure for all the details.

The whole building is most accurately proportioned in every part, and I think it not unlikely that it will be possible to find a standard which shall express every dimension without any incommensurable fractions.

I now proceed to that part of the subject which is more particularly the object of the present paper, namely, the optical corrections. I shall first state the case as I found it, and lastly, say a few words on the probable origin and intention of these subtleties, which prevail, more or less, in almost all the Greek temples—in all, indeed, that I have examined, with the exception of the temple of Bassæ, on the borders of Arcadia, where I could not find satisfactory indication of either convexity of pavement, or inclination of the columns, or even entasis.

The pavement of the Parthenon is bounded by four curved lines, viz., the edges of the upper step on the four sides of the building. The four angles of this curved surface are not precisely level, the south-west angle is about ·16 above the north-east and south-east angles. I think that this is simply owing to the lines of the earlier temple, which were also curved, being made use of as far as they would go, and by being produced in one direction only, and remaining fixed at the south-west angle. The line so produced would naturally fall below the fixed point. This is the case on the west front, south and north sides. The extreme points of the upper step of the east front are exceedingly near level. The result of a number of observations gives only a difference of ·002, or $\frac{1}{500}$ feet, a quantity which we need not stop to discuss.

If these two points be joined by a straight line, the curve which forms the edge of the step will be found under the middle columns to rise to a height of ·214 above it. If the uniform curve had been preserved, it would have been ·218 in the middle, which is about $\frac{1}{465}$ breadth of front; and the curvature is so regular on the northern half of this front, where the steps rise immediately from the solid unbroken rock, and consequently no settlement can have taken place, that of four points measured at the centres of each column, three agree exactly with a circular arc: the fourth differs only by ·003. The curvature is so very slight that it might be any regular continuous curve; for instance, in so small an arc no appreciable difference could be shown between the arc of a circle or that of an ellipse or parabola, and I think that the work was set out by means of the latter figure, which might be done very easily; whereas, I need scarcely point out the difficulty, or rather impossibility, of using the circle, which would require a diameter of about 2¼ miles.

Let it be required to construct a circular or other arc of uniform curvature, whose length is 100 feet, and the rise at the centre is to be ·25, or any other small measure which must not much exceed one foot. Construct with any axis a parabola, and set off from the vertex A B = the proposed rise, and draw L M at right angles with A B. Now, L M will represent the 100 feet horizontally, and ordinates drawn to the curve perpendicular to L M will determine the exact rise at as many points as may be required, full size.

The curve on the upper step north side of the Parthenon, also approximates to a regular curve very closely; its entire rise in the centre above the line joining its extreme parts, is ·356, which is very nearly in the proportion of $\frac{2}{3}$ of the rise in the east front: it is exactly $\frac{1}{810}$ length of the building. The curve on the south side seems to have been identical with the north side, but it has suffered more from the concussions which the building has undergone, especially as there is a great depth required on this side of artificial foundation. On the north side the steps rise almost immediately from the solid rock. The curve on the west front is not quite so symmetrical as on the other sides. It has, I believe, been affected by the lines of the old building. The rise is exactly the same as the east end.

The upper members on all four sides follow the steps, and are nearly parallel, but there is a little more curvature given to the steps; the entire rise of architrave is ·173 on east front, ·175 on west. The levels of those portions of the entablatures which remain on the north and south sides point out the directions which those lines had originally, and they were as nearly as possible parallel to the line of the step, excepting that just at the angle columns the step has a little the more declension. The frieze and cornice are exactly parallel with the architrave. In the temple of Theseus, also, these curves prevail; on the fronts the rise is $\frac{1}{700}$ part of its length, on the flank, $\frac{1}{930}$. The lines in the architrave are exactly parallel to the step.

There is one refinement which the temple of Theseus possesses, which the Parthenon is without. In addition to the cornice being raised, the inclined lines of the pediment have a very slight convexity, between ·02 and ·03. I was unable to fix more precisely the amount. I imagine that it was owing to some degree of haste in which the Parthenon was finished, of which there are several indications in the upper members, which prevented this final adjustment being made to its pediments; the state of the political horizon at that time making the completion of the long walls of more immediate importance than the optical corrections of the Parthenon. On a former occasion I stated my impression that the cause which led to the adoption of this convexity of the horizontal line, existed in the contrast of the inclined lines of the pediment.

Mr. Ferguson has kindly favoured me with an illustration, which I will read to you, from a description of the construction of an iron foundry at Kasipur, near Calcutta, built in the year 1834. The foundry is covered by a single roof, with principal rafters, tie-rods, and suspension bar from the centre. The rise is 6 feet and the span 50 feet, which is exactly the same pitch as the Parthenon and Propylæa. The passage is extracted from vol. iv. of the journal of the Asiatic Society of Bengal, p. 116: "Before closing our short account of the Kasipur roof, we must notice a curious optical deception, for which we are somewhat at a loss for a correct explanation. On entering the room and looking up at the roof, it strikes every beholder that the roof has somewhat sunk, and the horizontal tie-rod is about 5 or 6 inches lower in the centre than near the walls. We were not convinced that it was a deception until Major Hutchinson, at our request, caused an actual measurement to be made by a perpendicular wooden batten from an accurately adjusted level on the stone floor. It was then proved that there did not exist a difference of level even to the tenth of an inch." The conclusion is obvious that a straight tie-rod appeared to be deflected; and I have no hesitation whatever in ascribing the cause to the contrasting lines of the principal rafters. I do not think that it is necessary to have our eyes refined by a southern climate for the appreciation of these effects. I suppose that there are very few gentlemen here who have not felt the same disagreeable effect of a flat open roof with horizontal tie-beams, unless, indeed, the latter be very much cambered. That this was the view the ancients took of the matter I am convinced by these two facts—

That the great temple at Pæstum has the convexity only in its fronts, and not on its flanks; and in the Propylæa at Athens, although the base on which the columns of the two pediments stand is perfectly straight and level, the line of the architrave was curved. For enough remains to determine this in the eastern portico—the central columns are actually about ·12 higher than those at the angles. The base in this building is cut in two by the ascending roadway, so that there could have been little or no advantage in a convex base line.

It will be well to remember that the temples at Athens were the result of the experience of several centuries in which these refinements were gradually brought to perfection. The first process was probably to raise the cornice under the pediments and entablature, by making the middle columns a little higher than those towards the angles, as I have mentioned in the case of the Propylæa. Still it is likely that to a fastidious eye the straight line of the stylobate would appear weak. The second method would be that found in the great temple at Pæstum, in which the fronts have the convexity in their steps, as well as their entablatures, the flanks being composed with horizontal lines. Perhaps a reasonable man should be content with this. I must willingly admit that I was perfectly content with the temple at Pæstum; still nothing short of perfection could satisfy the refinement of vision with which the Greeks alone, among the people of all time, seem to have been endued; and perhaps by looking at a temple constructed as above-mentioned, anglewise, and contrasting the convexity of the corona of the fronts with the straight line of that on the flanks, or more likely the comparison of the two different forms of line on the stylobate, suggested the possibility of improvement; at any rate as early as the time of Pisistratus, the Athenians had begun to demand from their architects the perfected construction, as the foundations of the temple of Jupiter Olympus testify, which we know were laid during his reign.

I also refer to his time, the earlier temple of Minerva, which occupied the site of the Parthenon at the time of the Persian invasion, in which also we find that the lines on the four sides of the building were convex. I can bear witness also to convexity on all the four sides of the temple at Nemæa, in the Peloponnesus, and Segeste, in Sicily. I could find no trace of convexity at Corinth, Egina, Rhamnus, or Bassæ.

The next subject is the inclination of the columns and the upright faces of the building. 1st. The face of the steps inclines about ·008. 2nd. The columns incline, backward, a quantity, of which I obtained the following results. From the average of the measurements of all the lower drums, (*scamillæ impares*, as Vitruvius calls them) ·229. From plumbing the angular columns of the east front, taking into consideration all the cracks and movements which have modified its original position, I obtain two results of ·230 and ·232.

In the plumbing, I observed every precaution to ensure correctness, using a very heavy weight and also watching for calm intervals of weather, which are rare at Athens. I am disposed to think that ·228, or one thousandth part of the length of the building was the amount originally intended. Those gentlemen who remember the perfection of the joints with which the Parthenon is constructed, will allow that the openings between them, which at present exist, are the exact records of all the settlements which the building has undergone, and that by a careful examination of these, the original amounts may be exactly recovered, which would be hopeless in a building which had been of less highly-finished construction.

Vitruvius directs that the columns of the pronaos and posticum should be set perpendicular, and those of the peristyle should incline towards the cella. In Cicero ad Verrem, we have an amusing passage, in which Cicero relates one of his rascalities; that having under his charge, as Roman governor, a young Syracusan nobleman, whose property was subject to the condition of repairing the temple of Castor in that city, Verres was exceedingly anxious to make a job of this; so he goes to examine the temple, but was much disappointed on finding it in perfect repair, when one of his companions casually observed, there is nothing here to be done, unless you order the columns to be set perpendicular. Verres was evidently surprised at this observation, for he knew nothing of architecture, and to his eye the columns appeared angular; but it was mentioned to him by those who were around him, and no doubt familiar with the practice of the ancients, *fere nullam esse columnam quæ ad perpendiculum esse possit*—namely, that in a temple there was scarcely any column, which by the practice of the Greeks, could be perpendicular. Verres was delighted at finding something to set his young friend about, and said, "Oh, by all means let him set the columns perpendicular;" and no doubt he took care himself to superintend the payment.

The object of this adjustment is to correct an appearance of fanlike spreading from the base outward, which takes place in columns which are all perpendicular. It may be owing to this cause that, in consequence of the diminution of the columns, the spaces between them on the architrave are greater than those on the ground (for the eye quite makes allowance for the counterspread of the capitals). Again, owing to the greater depth of shadow behind them, the upper part of the columns will have apparently more strength of light, and consequently appear greater. The effect altogether produced will cause the architrave, if equal, to appear longer than the base, and consequently the angle columns will appear to lean outwards: this is rectified by making the said angle columns lean a little towards the centre of the building. It is a proof of the wonderful judgment with which this quantity was chosen, that so many diligent and accurate observers have studied and drawn these temples without being aware of the fact. When my attention was first called to it, I could not at all perceive it; and I greatly amused a French architect, who had been for some time at Athens, by asking him which way they leaned: after some days the eye began to take cognizance of it, and I could perceive which way it went.

The impression of strength and beauty resulting therefrom is by no means confined to those who are cognizant of the fact; and I doubt not that many of our earlier investigators have been astonished that the level-and-plumb imitations of Greek architecture which we have in this country so little recalled to their minds the consummate beauties of the Parthenon and other Greek buildings. No doubt our climate is unsuited to the pure Greek, but this is not enough to account for the falling off; it is not so in our Roman and Palladian buildings.

One peculiarity which I noticed is that the antæ lean forwards to meet the columns of the pronaos. This seems to have resulted from the inclination inwards of the columns of the peristyle; those of the pronaos and posticum being perpendicular, the effect would have been to produce a strong contrast between their different positions, and the artifice must have been detected: by the influence of the contiguous face of the antæ, the column (here drawn from the posticum), which is really perpendicular, is made to appear to lean slightly in the same direction as the outer columns.

I have observed that a perpendicular pilaster, when brought very near to a column in a portico or doorway, has the effect of making the column appear to lean forward. The inclination of the antæ is not itself visible, except to a spectator in the narrow space between the inner row of columns and the wall; and when the eye is brought very near to a line, so that it cannot take it in all at once, it is scarcely possible to judge of perpendicularity.

The last peculiarities I shall mention are the differences of the abacus. Those on the east front are of the largest class, the north-east and south-east having the largest in the whole temple; they are 6·858; the others in the east front are 6·755; on the south side they are 6·580, and so are they on the west front. The north-west angle is the same as the ordinary size of the east front, 6·755; the south-west angle is somewhat less; on the north side they are 6·750 in the middle, and regularly decrease towards the angles.

The entasis of the columns is the most wonderful and beautiful of all the curves. It is so delicate, that its existence was for some time doubted; and yet I found by careful measurements, in a manner which was suggested to me by Professor Willis, which I will here describe. A fine harp wire was strained from the top to the bottom, as tight as it would bear, close to the edge of such flutes as preserved a sufficient number of points, with the original surface, and by means of a rule similar to the one I here produce, which is supplied with a vernier, I was enabled to measure from the flute to the wire with the greatest accuracy to about half $\frac{1}{1000}$ foot. I took such measures in several columns of the Parthenon, which I found to be wonderfully true and identical. I measured also the entasis of columns from the Erectheum, Propylæa (both orders), temple of Theseus, and Jupiter Olympus. In those of the Parthenon, Erectheum, and Propylæa, I find the correspondence with hyperbolic arcs, which I have calculated so exact, that the mean of from 14 to 20 measurements in each column differs from the calculated curve less than $\frac{1}{1000}$ foot, and none of them, where the surface was to be depended upon, differs by so much as $\frac{1}{500}$. The entasis of Jupiter Olympus gives also a very true hyperbolic arc. The columns of Theseus are so much worn in their outer edges that I was obliged to content myself with measures within the flutes, which never give such regular curves as the fillets, although the flutes are worked with a nicety far exceeding that found in any other style of architecture. Still, a mean from four different sections within the flutes gives a very accurate hyperbolic arc, although no one is a perfectly regular curve. These hyperbolas are all chosen with their axes, multiples, or aliquot parts of the attic foot. The Greek architects acted with great judgment and knowledge of the nature of the curve they were employing, as it is the only one of the conic sections which can produce variety in such delicate curvature as they have chosen for their entasis.

I must now advert to some of their mouldings, which are worked with the same perfection, and, as far as I have examined, are all different forms of the conic sections.

The echinus of the capitals of all the Doric columns agrees with various forms of the hyperbola. The soffit of pediment, Parthenon, and Propylæa, and I think of Theseus also, shows a hyperbolic arc. This is a magnificent moulding, and worked with the utmost perfection. That of the Erectheum is an equally true parabola. The cymatium of the Parthenon is the only certain circular form which I know, except the torus of base, Erectheum, and Ionic order Propylæa. The flutes, also, are all parts of circles, whose centres are proportioned to the width of the flutes. In this they showed their judgment, as it would have been almost impossible to have worked pure ellipses; and in these retiring surfaces the value of the perfect variety of curvature of the ellipse would scarcely have been appreciated. Talking of flutes, there is a peculiarity in the flutes of the Parthenon, which does not occur in any other of the temples of Athens. The flute at the neck is deeper in proportion to its width than in the rest of the shaft: during the whole rise, until about 3 feet below the neck, the sagitta or depth of the flute, from its chord, is $\frac{10}{68}$ths of chord. At the neck it is $\frac{10}{57}$ths, which is about $\frac{1}{6}$th part greater. This has a good deal of effect on the column, and gives a richness of effect to the upper part, at the same time that it diminishes the light in that part where it can best afford it, viz., where it is contrasted to the deep back-ground of shade of the upper part of the cella wall.

I have not yet much to say with regard to the colouring of the temple, nor have I much time to say that little, for I fear I must have exhausted your patience. The drawings which are at present made represent the architrave, band, &c., the triglyph, and the string which carries the marble beams which supported the ceiling. There is not a great deal of positive colour remaining in the Parthenon. The underside of the mutules show some vestiges of blue and red colour, and the upper part of the nook of the triglyphs, here and there on the east front, preserves some blue. One of the antæ of the posticum has a tolerable supply among its eggs of blue and green, and some red. The flowers which decorate the cymatium and other mouldings have no trace of positive colour, but the drawing of the ornaments upon them is in many places clearly to be made out.

CAST AND WROUGHT IRON BRIDGES.—(PART II.)

(Continued from page 126.)

At the request of the council of the Royal Scottish Society of Arts, the second part of a paper "*On the Strength of Materials, as applicable to the construction of Cast or Wrought Iron Bridges, including an account of the Tubular Bridges over the Conway and Menai Straits &c.*," was read, April 10th. By GEORGE BUCHANAN, Esq., President.

In the first part of this paper, Mr. Buchanan described, on a former evening, the principle and construction of the High Level Bridge at Newcastle, which is intended to complete the communication by railway between London and Berwick-upon-Tweed. Some inquiry having been then made from the chair regarding the bridge over the Tweed, the only remaining link uncompleted between London and Edinburgh, he had received the following particulars from Mr. Harrison, the resident engineer under Mr. Stephenson: —This bridge is to be of stone, and is to consist of 28 semicircular arches, each $61\frac{1}{2}$ feet span, resting on lofty piers, carrying the level of the railway 103 feet above high-water mark, 126 feet above low-water mark, and 135 feet above the deepest part of the bed of the river. The whole length of the bridge, with abutments and wing-walls, is 2140 feet. The 28 arches are divided into two series by a broad pier, 28 feet in thickness in the middle. The piers of the arches are $8\frac{1}{2}$ feet in thickness at the springing, increasing by steps towards the bottom. The bridge will not be completed for 16 or 18 months, but it is intended to have a temporary bridge ready for traffic in the month of July next. This viaduct is a work of great magnitude, and will form, when finished, a striking and imposing structure, and one of the many to which the extension of railways has given rise. While on this subject, he would mention two other remarkable works, recently designed and executed by Mr. Miller on the North British and Ayrshire Railways. The one is the viaduct over the Valley of Dunglass, between Dunbar and Berwick, not far from the once-celebrated Pease Bridge. This viaduct crosses the valley and banks by six semicircular arches, each 60 feet span, and then the deep ravine by a single arch, 135 feet span, and rising 105 feet above the bed of the stream. A large and beautiful model of this structure was exhibited, which Mr. Miller, at the President's request, had allowed to be shown to the Society. The other viaduct is that of Ballochmyle, across the Water of Ayr, on the Cumnock Extension of the Ayrshire Railway, and is similar to that of Dunglass in crossing the valley on three semicircular arches, each 50 feet span on each side, but is still more remarkable in crossing the deep ravine in the middle by a single semicircular stone arch no less than 180 feet span, and rising 150 feet above the bed of the stream—a bold and noble design, and which has been executed with complete success, the adjacent rocks furnishing such vast blocks of stone as greatly to facilitate the construction, and to render, indeed, the plan itself practicable. The arch stones are 5 ft. 3 in. deep at the springing, and 4 ft. 9 in. at the crown, and the appearance from below of the stupendous arch rising to such a height is singularly grand and striking. The whole arrangements connected with the quarrying and raising and depositing the stones on the building, by the improved machinery of modern times, have been most efficiently conducted by the contractors, Messrs. Ross and Mitchell, and the simple mode of centering adopted and shown in the Dunglass model is recommended by the advantage of preserving the timbers entire.

The subject of stone bridges opens a wide and interesting field, but extending beyond the limits of this paper. He would, therefore, resume the one more immediately prescribed, namely, the strength of materials, particularly iron for bridges. Some interesting experiments, which the time on the previous evening did not permit to be shown, were then made on the tensile strength of stone from Hailes and Craigleith quarries. The Hailes stone bore on the square inch 360 lb., the Craigleith considerably more; and a remarkable effect was observed here after the load had hung for a little: it was suggested by a member to give it a slight tap with a hammer, and, on this being done, it immediately snapped asunder, showing the effect of vibration or concussion when the materials are greatly strained in aiding and completing the fracture, a circumstance which appears to throw light on what may sometimes occur by the rapid and violent actions of the trains on railways. The compressive strength of the Hailes and Craigleith stones was then shown, by experiment, to be much greater than the tensile strength; and as it required, indeed, more weight and a more powerful apparatus than could be commanded, these experiments on different stones were deferred to another evening.

The compressive strength on posts or pillars was then considered, and the remarkable effects of the length of the pillar in diminishing its strength. On this subject much light has been thrown by the experiments of Messrs. Hodgkinson and Fairbairn. Pillars or rods were tried of different lengths, from 3 inches to 5 feet, and of different diameters; rods half an inch diameter, with $3\frac{3}{4}$ inches length, bore 11 tons; but when the length was $7\frac{1}{2}$ inches it only carried 5 tons, when 15 inches long, 3 tons; and at 30 inches only 13 cwt. From these experiments, a general rule may be drawn for different lengths. Taking the strength of cast-iron as formerly given at 50 tons per square inch, this will hold good in pillars till the length reaches five times the diameter, and then it begins to diminish. When the length is ten times the diameter, the strength is reduced in the proportion of $1\frac{3}{4}$ to 1; with the length at 15 times the diameter, it is reduced as 2 to 1; 20 times as 3 to 1; and 40 times as 6 to 1.

Hence the great advantage in cast-iron, of using hollow pillars or tubes in place of solid metal, whereby, with the same area or section of fracture the diameter of the pillar is increased, and with it the resistance to flexure, and an increase of strength in proportion to the length. A solid pillar, for instance, 6 inches in diameter, if extended to $7\frac{1}{2}$ feet in length, would be weakened one-half, but if cast hollow, 10 inches in diameter and $\frac{3}{4}$ inch thick, giving the same weight of metal per foot in length, it might then be extended to $12\frac{1}{2}$ feet, and still possess the same strength as the other. In all these cases a remarkable circumstance was observed in regard to the mode of applying the strain. With the ends of the pillar turned flat, and a flat plate interposed at top and bottom, which is the case in supporting buildings, this was found to sustain nearly three times as much as when the pillar was rounded on the ends, so as make the force pass directly through the axis, as occurs so frequently in machinery with the connecting rods of steam-engines, and in other cases. The effect of the length of pillars in weakening the strength was illustrated by a striking experiment with a spiral wire, quite flexible, yet, when set up as a pillar, and tied in the middle laterally, with slender threads, carried a weight of 56 lb., and would have carried much more, but the moment the threads were cut, the wire gave way by flexure, and oversetting the balance, the weight immediately sunk.

In regard to the Transverse Strain, he had already explained the nature of this compound action, and particularly the manner in which, under it, the beam becomes exposed at once to the effects of tension and compression, the one side being distended and the other compressed. On this most interesting and important subject he had still much to say, but would defer it to another evening, as the time was short, and he was anxious to proceed with another part of the paper which had been particularly referred to, namely, the subject of the tubular bridges.

The application of malleable iron had been already used in the shape of tension-rods in cast-iron girders, and was applied, as we have seen, in the high level bridge at Newcastle; but the application of girders constructed of malleable iron alone is a new idea. It has been applied on railways in the case of skew bridges of wide opening and limited depth between the railway and the road; in these cases the girder consists of a rectangular hollow tube or square box, extending over the whole span, and of such depth as can be attained. These have hence received the name of Tubular Bridges, and have excited much attention since the grand experiment has been determined on, of trying these structures on such a magnificent scale as is now in progress of execution in the crossing of the Straits of Menai by the Britannia Bridge, and the estuary of the Conway by the Conway Bridge, and which form, without doubt, the most remarkable engineering enterprises of the present day. These spots, as is well known, had already been the scenes of vast engineering operations connected with the suspension bridges of Telford to form the great turnpike road communication from the metropolis to Holyhead, and thence across the channel to Dublin; and when it was determined that this communication should be superseded by railway, it became a matter of most serious consideration how these two openings were to be spanned, keeping in view the new conditions of stability required for railway traffic; and the subject having been remitted to Mr. Stephenson, the engineer of the line of railway, namely, the Chester and Holyhead, he at once rejected the principle of the suspension bridge as inapplicable, owing to the undulations to which it was liable, and which had been proved by practice in a similar bridge for a railway across the Tees, to be both inconvenient and dangerous. How far the principle might have been modified by the introduction of proper ties and braces may be a question; but in a case of such vast magnitude and importance there might still have been risk, and, on the maturest consideration, Mr. Stephenson determined to recommend the simple and bold design of a hollow rectangular tube of malleable iron, consisting of thin plates rivetted together, such as he had already tried with success on a smaller scale upon railway bridges, and which he conceived was the best form for securing not only strength, but sufficient stability and stiffness to prevent any undue oscillations or vibrations. To carry out this plan, the assistance of the first authorities, scientific and practical, on the strength of materials was called in, and to Messrs. Hodgkinson and Fairbairn the duty was remitted of trying the effect with experimental tubes on a small scale, and finally on a model one-sixth of the dimensions of the bridge, being 75 feet long. Much valuable information was obtained during the progress of these experiments. The first thing observed was the uniform tension of the under side of the tube when loaded, and the violent compression of the upper side, forming a beautiful illustration of the nature of the tensile and compressive forces already laid down. The former, by its uniform tendency to produce the stable equilibrium, bringing the thin masses into a straight line, the line and position of repose; but the latter, on the contrary, tending to produce flexure in the plates, to push them out of the straight line, and push everything out of joint; so that when the bottom plates remained firm, and retained their form, the top plates became bagged up and puckered like a loose web of cloth. The top plates were, therefore, strengthened, and the addition of another plate to the top increased the breaking weight from 3,700 lb. to 4,500 lb.

As it was not so much strength that was wanted on the top plate as stiffness, in place of adding layer upon layer of plates, the idea naturally occurred of forming the top plate into a series of little hollow square tubes running longitudinally the whole length of the bridge, having the appearance, looking endways, of little cells, the effect of which was such, that while the top plates remained firm, the bottom ones now appeared to give way. These being next strengthened, an extraordinary effect was then exhibited when the tube broke, the sides collapsing together, and twisting and distorting the whole fabric in a singular manner, showing that the sides formed now the weak point. These, then, were strengthened and stiffened by numerous ribs of angle-iron running vertically from top to bottom, and at last, by these repeated trials, the strength and proportions of the different parts of the structure appeared to have attained a fair and proper distribution. The strength of the tube, which at first only carried seven times its own weight, was then increased to eleven times, and from these experiments the strength and proportions of the real design have been calculated, and one of these tubes, as is known, has now been actually constructed on the shore of the Conway, floated by water to its place, and raised to its proper height by the power of two enormous hydraulic rams, one at each end, lifting the gigantic mass, which is 412 feet in length, 15 feet wide, $25\frac{1}{2}$ feet high, and weighing no less than 1,300 tons. This is intended for one set of rails, and there is another tube of the same dimentions in preparation to be set parallel to it for the other.

The situation of the structure close to the suspension bridge, and close to the base of the magnificent Castle of Conway, and the effect of spanning the wide estuary of the Conway, were all illustrated by a beautiful drawing, and the nature and construction of the tube or bridge itself, was illustrated by a model which he had himself constructed. The model was composed of only three thicknesses of paper and one of cloth, and the sides were strengthened by thin slips of wood to represent the angle-iron; it was 8 ft. 6 in. long, $6\frac{1}{2}$ inches deep, and $3\frac{1}{2}$ broad, and although weighing only 4 lb. it carried a weight of 32 lb. in the centre, without visible deflection.

The dimensions and structure of the bridge he would now describe, from information for which he was indebted to Mr. Fairbairn of Manchester, and, through Mr. Stephenson, to Mr. Edwin Clarke, the resident engineer under him.

The sides of the tube, which are $25\frac{1}{2}$ feet deep at the centre, consist of malleable iron plates, only $\frac{1}{2}$ inch in thickness, rivetted together in plates 2 feet broad and from 4 to 8 feet long (as was shown in an enlarged view or elevation with cross sections), adjusted so as that the joints may break band. At the joints, however, the strength and stiffness of these plates is greatly increased by slips of angle or T iron, one of which is laid on the outside of the plate and the other opposite to it on the inside, face to face, and all the four surfaces strongly rivetted together. The top of the tube, again, consists of two separate horizontal plates, running parallel to one another, 1 ft. 9 in. apart, forming together as it were a ceiling to the tube or tunnel and an external flooring on the top. These plates are $\frac{3}{4}$ inch thick, rivetted together in breadths of 2 ft. 9 in. thick, and in lengths of 6 feet, and between them there runs seven vertical plates longitudinally, from end to end of the bridge, 1 ft. 9 in. high and $\frac{3}{4}$ inch thick, separating the ceiling from the floor or upper platform, and at the same time uniting them strongly together by rivets and joints, each vertical plate having a rib of angle-iron on each angle, running longitudinally the whole length, by which it is united into one vast cellular mass, consisting of eight separate cells or tubes, 1 ft. 9 in. square. The object of all this strength and distribution of materials is to give the necessary stiffness and strength where the compressive force acts. And on this account the top and bottom plates are merely united by butt joints with covering plates. The whole sectional area of this cellular frame consists of 608 square inches. Lastly, the bottom of the tube consists of a similar frame of cells, but only six in number. The upper plate consists of two layers of plates, each $\frac{1}{2}$ inch thick, and the under one the same; but as these plates are intended to resist tension, and ought to be formed, if it were possible, like a chain, besides being laid in two layers, the plates are arranged so as to break joint, and a covering plate 3 feet long and as thick as the plate is placed over every joint with sufficient rivets, such that the tearing strain is equal to the tensile strength of the plates they connect. The plates are 12 feet long and 2 ft. 4 in. broad, being the whole breadth of the cell. The angle iron in the bottom cells and plates is rendered continuous by covers.

The top and bottom are united to the cells by strips of angle-iron running the whole length, inside and out; the interior vertical angle-irons at top and bottom are curved round to increase the strength of attachment, and there are also gusset or angle pieces rivetted on for additional strength. The rivets used vary from 1 inch to $1\frac{1}{4}$ inch diameter, and there are about a quarter of a million in each tube. The holes were made so as to make the rivets fit well, and they were all put in red hot. The sectional area of the bottom frame of cells is 508 square inches.

These are the dimensions in the centre of the tube, but the top plates become thinner towards the ends, where they are only $\frac{1}{2}$-inch thick, and also the bottom plates, where they are reduced to $\frac{1}{4}$-inch each. The side plates again get thicker towards the ends, where they are $\frac{10}{16}$ths thick. The ends of the tube are stiffened with cast-iron frames, and there are also castings in the cells for 8 feet at the ends, and the sides are also greatly strengthened at the ends. The tube was originally curved on the top 7 inches, and was brought to the straight line by the elasticity of the material as calculated on; showing that with its own weight, 1300 tons, it only sunk 7 inches. The one end of the tube is to be fast in the stone pier or abutment, the other is to be loose to allow of expansion, which has been found quite visible in different states of the atmosphere. Mr. Clarke says that the tube is a sensible thermometer,—half-an-hour's sunshine at one end, or on the top, will move it laterally an inch and a half, and vertically two inches, and this when the tube is loaded with 200 tons in the centre.

Such are the dimensions and structure of this extraordinary work, and in regard to which, he was happy to say, the trials which have been already made appear to promise every success. A load of 100 tons only sunk the tube 1 inch in the centre. In regard to the calculation of strength he was not able to enter on these at present for want of some of the data, but expected to do so on a future occasion.

The thanks of the Society were voted to Mr. Buchanan for his excellent and instructive exposition; and also to Mr. Stephenson, Mr. Fairbairn, Mr. Clarke, and Mr. Harrison, civil engineers, for communicating the information relative to the tubular bridges at Conway and Menai, and viaduct at Berwick; and to Mr. Miller, C.E., for allowing his elegant model of the viaduct at Dunglass to be exhibited. Mr. Buchanan was at the same time requested to continue his observations, and lay them before the Society at a future time, which request he kindly promised to comply with.

At the conclusion of the above paper, the following communications were read:—

1. "*On a new Lubricant for Machinery*" By Mr. Alexander Bryson.—This paper described a new compound, possessing properties which seem to render it a better lubricant than those in use for large machinery. It is composed of oil, sulphur, and vulcanised caoutchouc.

2. "*On Economising Fuel in Gas-Works.*" By Mr. William Kemp.—The author states that he has made a valuable discovery in economising fuel, at Galashiels Gas Works, by which almost all expense of fuel is saved. Where coal tar is burned, it has an injurious effect on the furnace bars and retorts, the greatest annoyance arising from the rapid clinkering up of the furnace bars, to remove which the firemen had frequently to throw water into the furnace, which caused the rapid destruction of the bars. To prevent this, the idea occurred to the author, of using the exhausted tan bark of the tan works, which had the desired effect. The force-pump for injecting the tar into the furnace was next thrown aside, as it was found that the dry bark absorbed tar equal to its production at the works. His method is as follows:—The bark is dried and mixed with the coke of the gas coal, bulk for bulk; a pailful of tar is thrown upon it, not quite so much as it will absorb, and it is then turned over. The mixture burns with a fine clear flame, attended with less smoke than formerly; the furnace bars, by remaining unclinkered, admit the oxygen freely for the combustion of the fuel. Where tan bark cannot be had, peat moss, loose and dry, makes a good substitute. The author states that in one year £126 was saved on furnace coal; and he has pledged himself that, in future, not a penny shall be required for that article.

3. "*Description and Drawing of a new Plate-Holder for the Daguerreotype Camera.*" By Mr. Andrew K. Sparke.

Mr. Sparke's plan is as follows:—A small mahogany box is made rather larger than three times the breadth of the plate, and half an inch on each end deeper; the width is three-eighths of an inch. A hole is cut in wood the size of the plate, and in the centre of the large pieces. In this box a veneer frame is made with a place for the plate and glass, on a line with each other; this is pulled backward and forward by a piece of wire or string, through a hole made at the corner. By this arrangement the plate is instantly exposed to the lenses, and will be found admirably adapted for taking moving objects. It saves the trouble of shifting the ground glass frame for the plate-holder, and the consequent risk of moving the camera, so annoying in the old plan. The plate is also exactly the same distance from the lenses as the glass. For a camera not achromatic, the ground part of the glass may be placed outwards, so that the plate will be the thickness of the glass nearer the lenses than the image seen on the ground glass, and consequently nearer or in the chemical ray.

INSTITUTION OF CIVIL ENGINEERS.

March 28, and *April* 4.—Joshua Field, Esq., President, in the Chair.

The paper read was "*The Engineering of the Rhine and the Moselle.*" By Mr. G. B. W. Jackson, Assoc. Inst. C.E.

This communication was written during a short visit made to Holland, for the purpose of inspecting personally the works with which the author had become familiar in the writings of Beaudemoudin, Vanden Bergh, Delafontaines, Hibbert, Krayenhoff, Ockhart, and Wiebeking. It commenced with tracing the geographical course of the Rhine from its source on the Badus, in the canton of the Grisons, to its numerous outfalls into the sea. It then treated at considerable length the geological character of the country through which the river and its branches thus traversed. The ancient works, as far back as the time of the Romans, were then briefly described; and the general state of the bed of the river, with the comparative levels, the inclination and the velocity of the stream, at the commencement of the modern works, were then laid down in a tabular form, as points of data; and then the capability of the Rhine for forming banks by warping, or depositing the matter held in suspension, was discussed. The remainder of the first part of the paper was then occupied by descriptions of the modes of straightening the bed of the river, and of constructing the dams, weirs, division arms, spurs, and shore works, and the method of blasting the rocks, which latter considerably impeded the course of the stream. Our limits will not permit us to follow the details of these works, which differ so essentially from any in our own country, but the whole proceedings appeared to be given with such precision, that the paper, when it is published at length, with the copious details with which it was illustrated, will form a most interesting portion of the minutes of proceedings.

The second part of the paper consisted to considerable extent of a translation of an account of the spurs, groynes, and other works on the Moselle, for restricting the dimensions of the bed of that river, and increasing the depth of water, so as to enable the navigation to be carried on, which would otherwise be averted in the low-water seasons. It was shown, that to effect this, numerous arms of the river had been dammed across, and allowed to silt up; the course had been straightened, elbows had been cut off, and the convex shores, after being silted up by deposit between the groynes, were defended by arming of fascines, &c. Division banks had been established for the inflowing rivulets, so as to carry the gravel to a greater distance down the stream. Rocks also were removed by powder, and general improvements to such an extent were executed, that the river was comparatively under good control.

The account of the Rhine was then resumed, and, after detailing the various plans that had been proposed for ameliorating its course, giving numerous interesting and valuable tables of Blanken's and Bolstra's experiments as to the tides, the inclination of the bed of the various rivers, the duration of the ebb and flow, and average height of the river at the time of new and full moon, the height of various dykes above the extraordinary flood-line, &c., the paper finished with these general views:—"On looking at the map of Holland, and tracing its various streams, it certainly does not appear singular that frequent stoppages should take place in that country, whilst such occurrences are comparatively rare in Germany; for, as long as the Rhine retains its single course, as at Emmerick, no obstacles, excepting elbows, stay the progress of the current seawards; but, as soon as it divides at the Waal and Pannerden Canal, the evil commences and increases, according to the number of arms and channels lower down. It is generally agreed that a river should have as few outlets as possible, in order to allow it the more effectually to clear itself; and that the tide should be admitted as far as possible, whilst at the same time, the action of the winds should be diminished; again, that the more the surface water of any river is obstructed, the more quickly the sand will accumulate; and also that, if a cut be made, it is usual for ice stoppages to take place below it, so as to raise the water-level above; and it is also agreed, that if a cut be made, as capacious as the river itself, or be permitted to increase to that extent, it will soon get beyond control, whilst the sand will accumulate rapidly—and that when openings exist in dykes, the ice gets into eddies, loses its velocity, and by degrees closes up the passage below the opening, so as to raise the water above. The question, therefore, to be solved with regard to Holland and the system followed there, in order to prevent breaches in dykes, and to save the better part of the country (taking into account its weak, marshy soil, and its incapacity to withstand any great force), is whether it be the better plan to relieve the pressure on the dykes, by cuts and new channels, and local floodings, at the expense of increasing the number of ice stoppages; and, at the same time, diminishing the velocity in the main rivers, thereby greatly augmenting its liability to accumulating sand. It is true, as already stated, that the rivers are at present in such a condition, that it must be very expensive to effect anything of importance; but the question is of such vital importance to the port of Rotterdam, and the certainty of the mouth of the Meuse at the Brielle in the course of time closing up like that at Katwyk, if no improvement be attempted, is so clear, that it is very much to be regretted some steps have not been taken ere this to prevent so great a flow of water from passing out by the Hollands diep to Helloet."

The author directs the attention of the Institution to this subject, and gives the following points for the consideration of the members:—"That the object to be aimed at, in any steps which might be adopted for improving the Meuse at Rotterdam, should be to protect and strengthen the shores and dykes likely to be operated upon by the alterations; to straighten all the curves on the Leck, so as to lessen chances of ice stoppages; to separate the Waal and Meuse waters as much as possible, and to lead off the former, together with the Leck, into the sea by the Brielle; to narrow the Bresbosch channel (now divided) into one, regulating the quantity of water; to close the Krabbe, the Noord, and the Spry, with sluice gates; and, for the purpose of widening the outlet, to join the Island of Rosenburg to the main land at Vlaardingen—thereby causing the ebb water to act upon this island, and with increased velocity and an additional quantity of water, attempting to remove the bar and shoals."

April 18.—"*Observations on the Resistances to Railway Trains at different Velocities.*" By Mr. D. Gooch, of the Great Western Railway.

For the purpose of performing the experiments, a dynamometer carriage was constructed at Swindon, in which all the results required were registered upon a large scale, on the same roll of paper, thus exhibiting at one view, and in the same period of time, the tractive power exerted upon the train, and the force and direction of the wind; the registration of the results was made upon the paper at every sixteenth part of a mile, and the time was registered in correspondence with the distance traversed during every fifth part of a second. The dynamometer spring used was 7 ft. 6 in. long, and very carefully arranged. It was only necessary to count the number of seconds, or fractions of a second, in one or more of the distance divisions, and the speed was accurately ascertained. The force and direction of the wind was ascertained by a wind gauge, placed 5 feet above the top of the carriage, with the connections brought down to pencils which indicated on the same sheet all the results. Indicator cards were also taken simultaneously from the steam cylinders as frequently as was practicable, but not continuously, as it was a service of some danger, the experimenter being obliged to sit on the buffer-beam of the engine at a velocity of 60 miles per hour, and in that windy position to take off four sets of cards in three quarters of a minute. The spot selected for performing the experiments was one mile of railway perfectly straight and level, and nearly on the surface of the ground; and in the plan the height of the trees, hedges, and every intervening object which could affect the influence of the wind is clearly marked. The experimental train consisted of first and second-class carriages, each on six wheels, 4 feet diameter, taken indiscriminately from the working stock, and loaded with iron to represent a fair load of passengers, giving a gross weight for each of 10 tons. The experiments were tried with various weights and speeds up to 100 tons and to 62 miles per hour, and the results were classified and arranged in a tabular form, with copious explanatory headings, so as to render reference to them exceedingly easy.

The author first reviewed the deductions of Mr. Wyndham Harding's formula, which was given at the discussion at the Institution in 1846, and gave his reasons for dissenting from that formula. He then examined critically several experiments recorded in the tables, stating candidly all the exceptions that could be taken to them; showing that although there was a difference of as much as 52 per cent. shown between the resistance as calculated by Mr. Harding's formula and the experiments made by Mr. Gooch, that difference might be accounted for by the methods employed by Mr. Harding, which were objected to, as calculated to produce erroneous results; viz., allowing carriages to run down inclines by their own gravity, using wheels of 3 feet diameter instead of 4 feet, having a much greater length of train for the wind to act upon, &c. He reviewed the great effect of a side wind against a train—driving the flanches of the wheels against the rails; and argued that the length of a train of carriages was much more important than its own weight. The author did not offer any formula that should be applicable for calculating the resistance of all railway trains; but his tables gave examples of almost every case that could occur, and thence data could be supplied for those who wished to carry the investigation further, and make a formula for themselves. He arrived at the conclusion that in practice the friction of the axle-journals was not a constant quantity at all speeds, and thought that the number and diameter of the wheels in a train, in proportion to the weight, should form elements in any general formula. He showed by experiments that the total atmospheric resistance to a train weighing 50 tons differed but slightly from that to a train of 100 tons weight, if the carriages were small and the train long in the one case, and the reverse in the other case.

The general result of the diagram of resistance with trains of 100 tons and with 50 tons showed that the resistance calculated by the narrow-gauge formula with a 50 ton train, at $62\frac{1}{2}$ miles per hour, was 37 lb.; with a train of 100 tons, by the same formula, at 61 miles, it was $31\frac{1}{3}$ lb. The broad gauge resistance, with a train weighing 50 tons, at $62\frac{1}{2}$ miles per hour, was under 23 lb.; and with a train weighing 100 tons, at $61\frac{1}{2}$ miles per hour, was $22\frac{1}{2}$ lb. We cannot, of course, give fully the results, except in a comprehensive form, but such were the general results.

The author concluded his paper by saying that it appeared to him necessary, before any general formula for calculating the resistances to railway trains could be made, that the value of the following elements, necessary in such formula, should be determined by experiments:—

1. The axle-journal friction, at different velocities and with different weights, per square inch of journal surface.
2. The resistance to the rotation of the wheels and axles per pair at different velocities and with different diameters.
3. The resistance due to the rolling of the wheels upon the rails, with different weights upon them, and with different diameters.
4. The resistance due to the passage of the train through the atmosphere, at different velocities, with different proportions of weight, and length and breadth of train.
5. The resistance due to the oscillation or unsteady motion of the train, at various speeds.

The author considers that all these values might be determined, with a considerable degree of accuracy, by careful experiment.

SOCIETY OF ARTS, LONDON.

April 12.—Sir J. V. BOILEAU in the Chair.

Mr. DIGBY WYATT, architect, read a paper "*On the Art of Enamel, Ancient and Modern.*"

The paper commenced with some remarks on the necessity of increasing the resources of the designers of metal work, by effecting changes in the process of manufacture; and by that act, producing a novelty which might possess all the charm of freshness, without any of that extravagance so constantly resorted to in the attempt to produce variety. The art of enamel presented this so much wished for desideratum, whereby by imitating the practice of the mediæval artists in this material, we might considerably enrich our industrial resources, and facilitate the execution of beautiful works of utilitarian art.

After a hasty description of the composition of pure enamel, and the nature of the pigments usually employed to colour it, Mr. Wyatt proceeded to enumerate the six leading varieties which had been adopted, at various periods in the history of the art, to unite the vitreous paste with its metallic base; endeavouring, as far as possible, to describe each genus in the language of some contemporary authority. The first, or Byzantine process, which obtained throughout the Eastern empire, from probably the time of Justinian, down to about the year 1300, was illustrated from the particulars furnished by Theophilus, the celebrated artist monk of the 11th or 12th century; and its chief peculiarity appeared to have been the formation of casements, or cavities, for the reception of the enamel, by means of gold filigree.

The second, or early Limoges style, which was so much practised in that city, from probably the 11th century, until the frightful siege and massacre by the Black Prince, was described from a comparison of the admirable notices of Mr. Albert Way with those of MM. Petit, Dussieux, Pottier, and the Abbé Texier; and would seem to have substituted for the filigree compartments of the Byzantine mode, incisions in the thick copper plate by the graver.

The third, or early Italian mode, practised for probably some 50 years before the days of Ugolino Veri, the artist who executed the celebrated shrine in Oevieto Cathedral in the year 1338, and carried on by subsequent goldsmiths and enamellers down to the end of the 16th century, was detailed from descriptions given by Vasari and Benvenuto Cellini; about the middle of that century it appears to have held a midway position between the ancient *champ levé*, or incised, and the painted enamels afterwards produced, consisting in engraving silver after the manner of medallic relief, and then floating it over with variously coloured transparent pastes.

Benvenuto was said to have, if not invented, at least been the first to describe the improvement that took place about the beginning of the 16th century, in the art which constituted what Mr. Wyatt called Jeweller's enamel. It consisted in using as a vehicle, with the glass powder employed to cover small gold or silver objects in the round, or in the highest relief, water in which pips of pears had been steeped. This held the paste in its place until vitrifaction took place, and was yet so delicate a cement, as in no degree to interfere with the perfect purity of the enamel.

The fifth, or "late Limoges" variety, was described as having sprung at once, fully armed, from the brain of that Jupiter of enamel workers, Leonard Limousin, under the auspices of Francis the First, and differed from its predecessors chiefly in covering the entire surface of the metal with an opaque paste, and then painting on it with transparent colours; regaining the effect of a translucent ground by applying silver leaf in particular situations, fastening it with a glaze of colourless enamel, and then tinting over it. These peculiarities, as well as the *peinture grisâtre*, and touching with gold, were illustrated from the interesting manuscripts published by M. Maurice Ardent, of Limoges. This style appears to have dwindled into nonentity under the hands of the Nouailhers, a family who lived (they can scarcely be said to have flourished) during the latter part of the 17th century.

In connection with the detail of the sixth and last process—the Miniature style—honourable allusion was made to the labours of Sir Theodore de Mayerne (whose interesting manuscript we may shortly hope to see published under the auspices of Mr. Heindrie) and his connection with Petitot, the principal and best known of this school of art. The improvements effected in this style would seem to have been a great enrichment of the palette, by the addition of new pigments, the power of multiplying the number of firings, and graduating the succession of tints, their hardness, and fusibility, by the addition of fluxes, &c. Unhappily, the mystery many selfish artists have thrown over their modes of procedure, renders them exceedingly difficult to analyse or describe.

Mr. Wyatt then commencing with Egypt, gave a rapid sketch of the history of the art, noting the barbaric enamels existent in the North, probably previous to the Norman conquests; touching on the connection between the Limoges and Byzantine schools; and tracing, though necessarily very briefly, all the salient points in its existence, both as a manufacture and as an art, in our own and other countries. He glanced at what had been recently done in the *ateliers* of Wagner and Rudolph, at Paris, and the exquisite paintings of Messrs. Bone and Essex; and concluded by expressing an earnest hope that the knowledge of art possessed by those gentlemen might soon be grafted on the skill of our workmen, and that we may ere long adopt, and fully carry out, the old practice of the middle ages, so ably characterised by the Abbé Texier, in his eloquent declaration that, "in those days, Art and Manufactures were blended and identified; Art gaining by the affinity great practical facility, and Manufacture much original beauty."

Sash Line.—Messrs. Newall and Co. have greatly improved their patent copper wire cord, which is now made extremely flexible, and is well adapted for window-sash-line, hothouses, lightning conductors, picture-cord, clock-cord, bell-hanging, and many other purposes for which hempen rope has hitherto been used; the advantages being that it is cheaper, much more durable, and one-sixth part the bulk of hempen rope.

COMPOSITION OF COAL GAS.

Extracts from a lecture, by Dr. A. W. Hofmann, *delivered at the Royal College of Chemistry, Hanover-square.*

The composition of gas evolved in the distillation of coal is by no means constant; on the contrary, it varies to a considerable extent, depending principally on the nature of the coals, the presence or absence of moisture, and the temperature at which the distillation takes place. The chief elements which constitute coal are carbon and hydrogen, with small quantities of nitrogen and oxygen; and, according to the quality of the coal, a larger or smaller amount of earthy matter. Another frequent ingredient is sulphur. This sulphur occurs almost invariably in combination with iron, in the form of iron pyrites. The quantity in which it exists varies very considerably; many kinds of coal contain so large an amount that they become altogether useless for the purpose of distilling gas. If coal be ignited, and atmospheric air excluded, a portion of its elements are evolved as gas, and the remainder become coke. The gases thus evolved contain carbon, hydrogen, nitrogen, oxygen, and sulphur. None, however, of these elements, except nitrogen, are found in an uncombined state among the products of the distillation of coal.

The following tables show the different combinations into which these elements enter during distillation. These combinations are very numerous, and are divided into two groups—viz.: substances which are solids or liquids at the ordinary temperatures, and compounds which present themselves at the common temperature in the form of gas.

COAL GAS NAPTHA.

Acid Portion.

Hydrate of phenyle	C 12	H 6	O 2

Neutral Portion.

Benzol	C 12	H 6
Toluol	C 14	H 8
Cumol	C 18	H 12
Napthaline	C 20	H 8
Paranapthaline	C 30	H 12
Pyren	C 15	H 3
Chrysen	C 12	H 4

Basic Portion.

Aniline	C 12	H 7	N 1
Picoline	C 12	H 7	N
Leucoline	C 18	H 8	N

NOTE.—The letters represent—C, carbon; H, hydrogen; O, oxygen; N, nitrogen, and so on; the figures designate the number of atoms of which each volume is composed—thus, one atom of aniline contains 12 atoms of carbon, 7 of hydrogen, and 1 of nitrogen.

The above series of substances are each of them highly interesting to the scientific chemist, whilst several are likely to become of high practical utility. These substances, along with others which are little known, constitute the complex viscid mixture called "tar;" and it is rather singular that many of them, in their separate form, are oils, possessing the most delightful odours.

The second table exhibits the different constituents of the gaseous products of the distillation of coal, as follows:—

CONSTITUENTS OF COAL GAS.

Name of Constituent.	Proportions.	Spec. Grav.	Products of Combustion.
Hydrogen	H	0·0691	Water.
Light carburetted hydrogen	C H 2	0·5528	Water and carbonic acid.
Olifant gas	C H	0·9674	
Volatile hydrocarbons	C n H n		
Carbonic oxide	C O	0·9674	Carbonic acid.
Cyanogen	C 2 N	1·8010	Carbonic acid and nitrogen.
Sulphide of carbon	C S 2	——	Carbonic acid and sulph. acid.
Sulphuretted hydrogen	H S	2·0620	Water and sulphureous acid.
Ammonia	H H 3	0·5897	Water and nitrogen.
Sulphureous acid	S O	2·2114	——
Hydrochloric acid	H Cl	——	Incombustible gases.
Aqueous vapour	H O	——	
Nitrogen	N	0·9720	
Carbonic acid	C O 2	1·5203	

In this table, the first is *hydrogen*, one of the constituents of water. From it is obtained a colourless transparent gas, remarkable for its low specific gravity, being one of the lightest substances known. It burns with a pale flame, requiring ½ a volume of oxygen, or 2½ volumes of atmospheric air, for its combustion. It is not, however, the luminous principle of coal gas. The next, *light carburetted hydrogen*, or *marsh gas*, is a compound, combining a proportion of carbon with two equivalents of hydrogen (C H 2). This gas, along with carbonic acid, is produced by the putrefaction of vegetable substances under water—hence its name of *marsh gas*. It burns with a pale bluish flame, rather more substantial than that of hydrogen—though it is also evident that it could not be, any more than the other, the illuminating principle of coal gas. The chief constituent of coal gas is *olefiant gas*—a name derived from its property of producing, when in contact with chlorine at the common temperature, a peculiar aromatic oil (of which a specimen was exhibited). It very much resembles chloroform, and no doubt but that it has also the same remarkable properties. It is far richer in carbon than marsh gas, the per centage of the latter being only 75, while that of the former is more than 85. Olefiant gas burns with a beautifully brilliant flame, and constitutes the true illuminating principle of coal gas. It requires for combustion to one volume of olefiant gas, three of oxygen, or 15 of atmospheric air. Marsh gas is composed of one atom of carbon, and two of hydrogen; while olefiant gas combines the two in equal quantities. There is, therefore, a large amount of carbon in this gas, which may be proved in a striking manner, by lighting an admixture of one volume of olefiant gas with two of chlorine, which will produce hydrochloric acid, and deposit all the carbon contained in the gas in a cylinder, in the form of a dense smoke, which renders the gas perfectly opaque.

Volatile hydro-carbons was the next constituent, but with respect to which, at present, there was not much known. The first table contained the names of several substances which had been extracted from the liquid products of the distillation of coal, called tar. These substances differed much with regard to their physical properties—some of them boiling only at very high temperatures, while others volatilised at a heat far below that of boiling water. It was evident, then, that the gas, generated along with these liquids in the retort, would carry off a certain quantity of these hydro-carbons—varying with the distance from the works at which the gas was examined. The great importance of these hydro-carbons in the luminous effects of coal gas would become obvious if their composition were considered. Benzol, for instance, contained not less than 92 per cent. of carbon, a far greater amount than that of even olefiant gas itself. This was proved by inflaming a small quantity of the liquid, so as to allow it an insufficient quantity of oxygen for complete combustion; and, in this way, a large portion of the carbon was separated. When mixed with a due amount of oxygen, the combustion of this liquid afforded a splendid light.——[The talented lecturer showed this, by passing a current of atmospheric air through the lighted benzol; and also illustrated the peculiarly rich illuminating power of this vapour, by passing it through the pale and almost invisible flame of hydrogen, which, when thus combined, gave out a volume of light, which gradually and steadily increased in vividness, until the eye could no longer bear its dazzling brightness.]

Carbonic oxide was the next constituent. Carbon combined with oxygen in two proportions, forming two compound gases; the one containing the smallest proportion of oxygen was called *carbonic oxide*; and the other, containing the largest proportion, *carbonic acid*, which appeared as the last item in the table. Both these gases were colourless, but their properties exhibited a striking difference. Carbonic acid was not inflammable, whilst carbonic oxide burnt with a pale blue flame, of little or no luminous power. Again, the latter was quite insoluble in water, while the former dissolved, particularly when the water contained a little alkali, so rapidly as to form a vacuum.—[This was illustrated by experiment.] This solubility rendered easy the removal of carbonic acid from coal gas; but no method had been discovered of separating carbonic oxide, which burns with gas, though it adds nothing to its illuminating power.

The other gases were produced in the distillation of coal gas in very small quantities; he should, therefore, only briefly notice them. There were two more compounds of carbons—the one with nitrogen, and the other with sulphur; the former of these were called *cyanogen* and the latter *sulphide of carbon*. Cyanogen was distinguished by its beautiful violet flame—carbonic acid being produced in its combustion, and nitrogen set free. It was also remarkable for its solubility in alkalies—cyanide of potassium being produced, which, with ironsalts, yielded Prussian blue. This gas occurred in coal gas in such small quantities, that its presence might, for a long time, have remained unknown, but for the very delicate test chemists possessed for cyanogen, by which the smallest traces could be detected. Sulphide of carbon was highly inflammable, burning with a blue flame, and producing carbonic and sulphureous acids. These substances had been actually found in coal gas, though they were by no means produced from every kind of coal.

Sulphuretted hydrogen was the next substance on the list; it was, however, invariably generated, and that too frequently in considerable quantities. Sulphurets of iron, or iron pyrites, which were disseminated through the mass of the coal, was the source of this gas; and its quantity, therefore, depended upon the amount of that mineral in the coal. Sulphuretted hydrogen was also the offensive principle in the exhalations from putrefying substances containing sulphur. Sulphuretted hydrogen was a colourless gas, burning with a pale blue flame; it had not only a most offensive odour, but produced a most deleterious effect upon health, even when mixed with a large proportion of atmospheric air. He had frequently witnessed, in the laboratory, fainting produced by the inspiration of this gas incautiously. Professor Faraday had proved, that a dog would die in an atmosphere of which 1-800th only was this gas; and that a bird could not exist if the gas formed only 1-1500th of its breathing medium. Fortunately, this gas was converted, by combustion, into sulphureous acid, which was very much less dangerous and offensive. It was necessary, however, in making coal gas, to obliterate every trace of sulphuretted hydrogen, for the sulphureous acid it produced, although far less injurious, independently of its effect upon health, attacked very readily every metallic surface. Besides, the small quantity of sulphuretted hydrogen which would escape unburnt between the turning of the cock and the ignition of the gas at the burner, and by leakage, was sufficient to destroy lead, painted, gilt, or silvered articles, in a very short time. The presence of sulphuretted hydrogen might easily be detected in gas, by submitting a piece of paper, moistened with the solution of acetate of lead, to the gas uninflamed.

Ammonia was another product, largely found in the distillation of coal gas, into which nearly all the nitrogen contained in coal was converted. Ammonia was a colourless gas, which, of itself, was very difficult to inflame, though, when mixed with other combustible gases, it was entirely consumable. Respecting the products of the combustion of ammonia, accurate experiments were still wanting. According to all known analogies, they were certainly water and nitrogen. Many works had stated that nitric acid was also produced; but he could find no actual grounds for this; and he believed, like many other such statements, it had been copied from work to work, and repeated until it had become received as a well-established fact, without the slightest claim to such a consideration. In all his experiments, he had never been able to find the smallest trace of nitric acid. Ammoniacal gas was very soluble in water, more so still in acids. The great avidity with which it was thus absorbed, rendered its separation from coal gas very easy.

Sulphureous acid was the product of the combustion of sulphur in the coal; and *hydrochloric acid* from the decomposition of some chlorides, when they were present in the coal. *Aqueous vapour* was the result of moisture in the coal. The *nitrogen* in coal gas was the residue of the atmospheric air contained in the retort—the oxygen of which was expended in converting a portion of the carbon and sulphur of the coal into carbonic oxide, carbonic acid, and sulphureous acid. Nitrogen was a colourless, transparent, and incombustible gas, which, being soluble neither in acids nor water, could not be separated from the coal gas. *Carbonic acid* had been considered with carbonic oxide, and that completed the whole of the constituents of coal gas.

The *illuminating principles* of coal gas were olefiant gas and the vapours of volatile hydro-carbons: there were also three other gases burning in the coal-gas flame—namely, hydrogen gas, carburetted hydrogen or marsh gas, and carbonic oxide. Besides these, the gas which we actually burn might contain traces of sulphuret of carbon and nitrogen—all the rest having been, or ought to have been, perfectly separated in the different processes of purification which the gas had to undergo. During the progress of the foregoing short description, the audience had already become acquainted with the manner in which these constituents singly burnt, but they would best obtain a correct idea of the contribution afforded by each, and the illuminating power of coal gas, if they were all lighted at once.—[Dr. Hofmann then lighted the burners attached to the vessels containing the separate constituents, so as to afford a view, at the same moment, of all the various flames.]

By the process of purification which coal gas underwent before it was fit for use, the cyanogen compounds, the sulphuretted hydrogen, the ammonia, the sulphureous acid, and the hydro-chloric and carbonic acids, were separated; and he proceeded to illustrate this process by passing coal gas, containing several of the above gases, through lime water mixed with a little potash; after which the liquid, which before was tolerably clear, became quite turgid, and the gas no longer contained the deleterious constituents.

The lecturer then proceeded to devote a few moments to describing the manner in which the distillation was effected on a large scale. In the infancy of the manufacture, the coals were distilled in iron pots, but now iron vessels of a cylindrical form were used. These were placed horizontally in a furnace—one fire heating five of these retorts. The shape of the cylinders was not unimportant; and, after various changes, ear-shaped cylinders were now generally preferred—its heating surface being greater than that of any other. The front of the retort, or mouth-piece, as it was technically called, was fixed by screws—iron cement being placed between the flanges to render it air-tight.—[These arrangements, as well as that by which the lid was fixed, were illustrated by drawings and a model.] The lid being fixed, the gas passed through a system of pipes into what was called the hydraulic main—a long, wide, horizontal pipe, half filled with water. Each retort was thus perfectly isolated, and the end of the pipe being kept immersed in the water in the hydraulic main, any one of them might be opened in order to charge it afresh, without fear of the gas already generated rushing back through the opening. The temperature of the hydraulic main being comparatively low, a large quantity of tar and ammoniacal water was collected in this tube, which flowed into cisterns erected for the purpose. From the hydraulic main the gas passed into a system of refrigerating pipes—the temperature of which was kept low by a constant current of water, whereby another quantity of tar and ammoniac was separated. The gas entered next into the purifiers, respecting which he could not now enter into the various ingenious contrivances proposed by various clever gas engineers and chemists. It would, perhaps, suffice, if he stated merely, that now the gas was forced through hydrate of lime, merely moistened with water.

In conclusion, he begged to offer some general remarks upon the combustion of coal gas. In enumerating the constituents of coal gas, he had pointed out those compounds which must be considered as impurities, and which must be separated before combustion took place; but, at the same time, there were others, contributing little or nothing to the illuminating power of the gas, which, when once formed, could not be separated from the gas. These were hydrogen, marsh gas, and carbonic oxide. Were these, then, to be considered also as impurities? If the gas were used for illuminating purposes, to a certain extent at least, they must be considered as impurities, because they were burnt, and in their combustion, a large amount of heat was evolved; the products of their combustion impaired the salubrity of the atmosphere in which such a light was burning, and no actual benefit or increase to the illuminating power was derived from them. If, then, there were no means of separating these substances when once formed, an effort should be made to prevent their formation. With regard to carbonic oxide, it would be difficult to find a method which secured us against its formation—the entrance of the retort, when being charged, being in commnuication with the atmosphere. It was, however, in the power of the gas manufacturer to diminish the amount of carburetted hydrogen, and especially of hydrogen. If the temperature of the retort were too high, a large quantity of the olefiant gas contained in the coal would be converted into marsh gas, or even into hydrogen. That this was often actually the case, appeared in a most striking manner, from the following analysis, made long ago, by Dr. Henry, of coal gas made from Wigan coal:—

Analysis of Gas from Wigan Cannel Coal

Time of Collection.	Specific gravity.	CH, or olefiant gas.	CH_2, or marsh gas.	C O.	H.	N.
In the first hour ..	0.650	13	82·5	3·2	0	1·3
	0·620	12	72	1.9	8·8	5·3
	0·630	12	58	12·3	16	1·7
5 Hours after the	0·500	7	56	11	21·3	4·7
10 commencement..	0·345	0	20	10	60	10

It would be seen by this table, that it was of the greatest importance that the heat in the manufacture of gas should not be carried to too great an extent. In the first hour, 12 parts of olefiant gas, and 72 of marsh gas, were evolved—while only eight of hydrogen were generated. At the end of 10 hours, not a vestige of olefiant gas was traceable; while the hydrogen amounted to 60—evidently the consequence of the olefiant gas being decomposed by the excess of heat. It had been found that, if pure olefiant gas were passed through a particular temperature it became changed into light carburetted hydrogen and carbon. The ratio of this decomposition was as follows:—

$$C_2H_2 = CH_2 + C,\ CH_2 = H_2 + C$$

So that it would be seen, that by a judicious arrangement of the heat of the retorts, the production of hydrogen and light carburetted hydrogen, which increased the bulk without increasing the illuminating power, might be kept within certain limits. A very small quantity of these substances might be present in coal gas without injurious effects, as they then served for the suspension of the vapours of the oily hydro-carbons. A mixture, indeed, of these vapours with carburetted hydrogen, in due proportions, might be considered as an equivalent to olefiant gas. Benzol, for instance, contained 92 per cent. of carbon; while olefiant gas itself contained only 85 per cent., and carburetted hydrogen only 75 per cent.; and, therefore, by an admixture of the latter with benzol, the illuminating power of olefiant gas might be obtained. Here, again, he would mention the beautiful process proposed by Mr. Low, for increasing the illuminating power of coal gas, as based upon the most scientific principles. If he wanted to express its nature in a sentence, he should say it was a process for converting a mixture of hydrogen and light carburetted hydrogen, by passing it through naptha, into olefiant gas.

This naturally led to the question—Why did hydrogen possess no illuminating power at all? and why was the illuminating power of marsh gas so far short of the beautiful light produced by a jet of olefiant gas?—and, briefly, in what consisted the illuminating power of olefiant gas? The illuminating power of gas depended upon a portion of it being separated in the solid form, which, being deposited at a certain distance between the orifice of the burner and the rim of the flame, entered into a state of ignition, from which the light emanated. Now, the composition of coal gas was such, that if it were allowed to issue from a convenient burner, a complete combustion of the hydrogen was obtained, but only a partial one of the carbon. Another portion was separated—that which entered into a state of ignition being heated to a white heat before it reached at sufficient temperature for its combustion.

In the flame of coal gas, three different parts, or cones, might be distinguished. Immediately over the burner, it was principally hydrogen which was burnt, along with a little carbon, whilst the main portion of the carbon being thus set free, was ignited in the second cone, and consumed with the rest of the hydrogen in the outer flame. By a simple arrangement, the illuminating power of the coal gas might be destroyed altogether—namely, by mixing it, previous to combustion, with a sufficient amount of air to produce a complete combustion. The illuminating power of coal gas—and, in fact, of any flame—depended entirely upon the deposition of a fixed body in the flame. It was by no means necessary that this body should be carbon. It might be anything else—such as lime, iron, &c.—[The talented lecturer then rendered the flame of hydrogen luminous, by passing through it a chloro-chromic acid; and this interesting lecture was concluded by several clever experiments, illustrative of the various subjects it embraced.]—*Mining Journal.*

STEAM WORKING EXPANSIVELY.

On the Influence of Rapid Motion of the Piston upon the Effect of Steam in Engines working Expansively: with Experiments upon the subject. By M. Paltrineri.—(Translated for the *Journal of the Franklin Institute.*)

The researches and numerous experiments which I have made upon the application of motive power to machines, and particularly my experiments upon the effect of springs, have convinced me that in the expansion of steam there is a loss of power: a loss which should have a certain relation to the number of superimposed strata of steam which occupy the cylinder, from its bottom to the piston.

These strata, moving with the piston, should naturally develope themselves, in order to follow and push it; and it is in this development of strata, one after the other, that the steam must employ a portion of its force, a portion which is certainly lost to the engine. The greater the number of strata, the more rapid is their development; and the more power that is thus absorbed, the less will there remain for useful effect.

Suppose the steam introduced into a cylinder to be intercepted at the moment when the piston has reached a fourth or a third part of its stroke, to give place to the expansion: from this moment we may imagine the fluid mass divided into a determinate number of successive parallel strata, and beginning to develope and expand themselves to drive the piston and follow it. It will then be apparent that the stratum nearest the piston will, without doubt, be able to exert upon it all its effort, and all the rapidity of which it is capable; but it will be also apparent that the one which follows cannot do as much, because the preceding stratum constrains it, by pushing it backwards at the same time that it forces the piston forwards. By its condition as an elastic fluid, steam should naturally expand every way, and maintain at the same time, as is admitted, a uniform density throughout its volume—consequently, the stratum which drives the piston on one side, repels, on the other, at the same time, the stratum which follows it, although allowing itself to be penetrated by it; the latter repels the one which follows it, and so on to the last, which is at the bottom of the cylinder.

There must, therefore, be a collision between one stratum and another, on account of the difference in their velocities, and of the necessary compenetration of one stratum into another, in order that the uniformity of density may be maintained. This collision must evidently produce a loss of power—a loss which should be proportional to the differences of the velocities, and which will be the more considerable according as the number of successive strata is increased, and as the expansion takes place more quickly.

It is from these considerations, confirmed by the results of experiments upon the effect of helical springs, that I am persuaded that a given quantity of steam, working by expansion, will produce more disposable and useful effect acting upon a piston of a large surface and short stroke, than upon a piston of smaller surface and with a stroke proportionably longer, all other circumstances being equal. Desirous of determining the truth of this opinion by rigorous experiment, I caused two steam-engines to be constructed under conditions strictly equal, and calculated to produce the same dynamic effect, according to admitted principles. But in one of them, the relation of the surface of the piston to the length of the stroke was in an inverse ratio to that of the other: that is, if one of the pistons had a surface of 20 and a stroke of 24, the other had a surface of 80 and a stroke of 6; so that the volume produced by the movement of one piston is precisely equal to that of the other. There is, therefore, exactly the same quantity of steam entering and leaving the two cylinders at each stroke of the piston, and, consequently, when the number of strokes is the same, in a given time, in each of the two engines, it ought to be certain that there is the same volume of steam, in the same physical and mechanical conditions, used by each cylinder. These experiments, of which a table is given, were made with all possible precaution, in order that all the conditions of the apparatus should be identically the same; they were repeated several times, on different days, and in the presence of several competent persons.

The following table shows the mean of the results obtained in several series of experiments, the apparatus being always kept under the same conditions:—

No. of Experiment.	Kind of Cylinder	Weight on the Break.	Revolutions per minute.	Virtual velocity of end of break lever.	Pressure on Steam gauge.	Cut off, or space for expansion of steam.	Effect, in kilograms raised 1 metre per second.	Ratio of Effect between the two engines.
		Kilogs.		Metres.	Atmosp.			
1	Wide	1·814	150	7·854	$\frac{4}{10}$	Full.	14·247	1·00
	Narrow	1·614	150	7·854	$\frac{4}{10}$	Full.	12·676	·88
2	Wide	1·754	168	8·796	$\frac{9}{20}$	$\frac{1}{2}$	15·428	1·00
	Narrow	1·418	168	8·796	$\frac{9}{20}$	$\frac{1}{2}$	12·472	·80
3	Wide	2·127	174	9·110	$\frac{6}{10}$	$\frac{2}{3}$	19·376	1·00
	Narrow	1·277	174	9·110	$\frac{6}{10}$	$\frac{2}{3}$	11·633	· 0
4	Wide	2·116	156	8·168	$\frac{8}{10}$	$\frac{5}{6}$	17·283	1·00
	Narrow	0·916	156	8·168	$\frac{8}{10}$	$\frac{5}{6}$	7·481	·43

The numbers in this table will show, at a glance, the difference of effect between the two engines. Although every precaution was taken to avoid error in the measurements and observations, and though the numbers in the table only show the mean result of several series of experiments, I do not assert that the ratios there given are strictly those which should result from the physical law of this phenomenon. New experiments, with engines of greater power, and an exact calculation with regard to the results obtained, can alone establish, with the accuracy desirable, all these relations. I believe, however, that the reasoning upon which my opinion is founded, and the results of the experiments which go to confirm it, authorise me to make the following conclusions:—

1. That the velocity of the piston has a much more remarkable influence upon the useful effect of steam than has been heretofore supposed.

2. That this influence is very greatly increased, and according to a certain ratio, on account of the amount of expansion which is allowed to the steam; the greater being the expansion, the greater is the difference of effect.

3. That in order to obtain from steam the greatest amount of useful effect, it is necessary to use cylinders as wide and short as may be practically convenient, and that the piston should move at a very low velocity.

It is certainly not unknown that the effect of steam has a relation to the velocity of the piston; but it has not yet, so far as I know, been recognised that the velocity of the piston has a particular and considerable influence upon the effect of the expansion; and I believe myself to be the first who has directed attention to this subject, and who has sought to demonstrate the truth by experiment. The numbers in the table show, in effect, very considerable differences, although the velocities of the two pistons appear only in the ratio of 1 to 4. The experiments mentioned have manifested two other phenomena which have attracted my attention, and which I recommend to the notice of scientific persons: the first is, that in the engines which I used, and when they were worked by expansion, the pistons were compelled, in some of the experiments, to complete their stroke while having against them (on account of atmospheric pressure) a resistance stronger than the force by which they were impelled. The other phenomenon is relative to the work done by the two engines. In most of the experiments made, the useful effect, as measured by the break, was always, and even considerably, more than the theoretical effect of the motive power. Does this difference of effect depend upon the partial vacuum created in the escape-pipe on account of the rapid passage of the steam, so that the pressure upon the piston has a relatively greater force? May this rarefaction in the escape-pipe also account for the continuance in the stroke of the pistons, although they may have been placed in equilibrium by atmospheric pressure before making a half, or two-thirds, of their stroke?

All these questions, the importance of which will be readily perceived by men of science, have need of study and elucidation, by experiments, perhaps of a different kind. On my own part, I shall do all that I can; but I call for the aid of learned persons who are conversant with such matters.

ROYAL POLYTECHNIC INSTITUTION.

This Institution was re-opened at Easter, although the additional buildings are not quite completed. When this is done, there will be greatly-increased accommodation, for the whole building will be doubled in size. The grand theatre will be one of the largest of the class in London, and capable of holding fifteen hundred persons. The screen is likewise of colossal size, so that a vast picture can now be shown on it, with all the resources of powerful instruments. Thus the Institution is in possession of a dioramic exhibition of much greater power, and possessing much more variety than any in London. In the illustration of microscopic objects, the great screen is likewise a valuable accessary, and its results present a striking contrast to what used to be a state of microscopic illustration, but a few years back. The old great theatre has been very much improved, and is now reserved for chemical lectures, the small chemical theatre at the other end of the Institution being devoted to purposes of exhibition. The grand theatre is accessible from three floors of the central hall, so that it can soon be filled and cleared, which is a great convenience to visitors. Over the screen room is a kind of bazaar of objects of ornamental art, consisting of porcelain and glass works, of great merit, from the establishments of Alderman Copeland and others. They show, even more effectively than the exhibition at the Society of Arts, the great progress of these important arts in England. When the front of the Royal Polytechnic Institution in Regent-street is finished, it will make one of the finest buildings in the street, and a very great ornament to it. The alterations have, it is understood, been made chiefly through the exertions of Mr. Nurse, the chairman of the Institution, who has evidently spared no pains or expense, and has succeeded in giving to the metropolis an establishment of a very high class, equally useful and ornamental. The works are such as to do great credit to the skill and taste of Mr. Thomson, the architect.

NOTES OF THE MONTH.

The Art-Union.—The report shows that there has been a falling-off this year of £5,000 in the income. This may be partly attributed to the badness and partly to the threatened government interference, but mainly to the reaction consequent on mismanagement and want of taste. The engravings have caused disappointment to the subscribers, and brought shame upon the committee. Their commercial value has long since been settled, the print with frame and glass being sold at the picture-dealers for seven shillings and sixpence. The engravings have not illustrated any subject of legitimate interest, and have wanted the character of high works of art; their utmost merit being that of middling wall-hangings. Upon such taste, thousands of pounds have been spent most wastefully, for any jobbing engraver could have turned out the whole lot of engravings at a much less price. In example and in practice, the administration of the Art-Union is equally bad, and is very unfavourable to the true interests of art. The plan of prize casts is most illiberal, for it is little better than desecration to break up a mould for the purpose of preventing more impressions from being taken. We must admit that there is no hope of the Society being more useful, even if the control of the prize-money should be taken from the prize-holders, and given to the council,—for the latter have shown their incompetency in everything they have undertaken, like most self-elected bodies.

Paper-hangings prepared by means of Nitrate of Silver and other Salts.—M. Larocque presented a paper to the *Academie des Sciences*, Paris, explaining a new process for colouring and designing paper-hangings. He observes, that nearly all the salts are volatilised under the influence of vapour from water or saline solutions, and that the nitrate of silver, among other salts, on account of its easy reduction, would furnish a great variety of shades of colour; and by means of reserves made in the paper, any designs in white might be obtained. The following is the process employed:—"Take of pure nitric acid, sp. gr. 1·50, two parts; and distilled water, one part. Place the mixture in a porcelain capsule and heat it, throw in about two ounces of silver, and continue to apply heat until the action of the acid on the metal has ceased; with this quantity of silver 700 or 800 sheets of paper may be coloured. In this operation but a very small loss of silver will be found, for the residue can be formed into nitrate of silver and sold; or, if calcined at a red heat in a crucible with carbonate of soda, the metallic silver may be obtained and employed for a new operation. In order to obtain good designs, it is necessary to operate in a place well lighted and out of currents of air.

Quarrying Machine.—"We took occasion (says the *Newcastle Chronicle*), a few weeks ago, to notice a new stone-drilling machine, and that it would shortly be tested upon some of the quarries in the neighbourhood of Newcastle. We can now state the result of a trial made upon the quarry of Mr. R. Cail, near Gateshead. The machine was put in motion by four men, and worked for an hour and a half, when they attained a depth of 8 feet, of 4 inches gauge. The hole was then charged with 19 lb. of powder, and the discharge produced the removal of 5,400 cubic feet of rock. We understand that it is likely to be very greatly patronised by quarry owners, from the rapidity with which it does its work."

Chemistry of the Sea.—A lecture was delivered on this subject at the Royal Institution, by Dr. Thomas Williams, of Swansea. In commencing, the lecturer demonstrated, by means of an apparatus contrived for the purpose, the effects of pressure on fishes at definite depths beneath the surface of the sea. Having shown that a gold fish, when the water in which it was placed was subjected to a pressure of four atmospheres, became paralyzed, Dr. Williams stated the following conclusions as deduced from his own experiments:—1. That round fishes, having an air bladder, cannot, without injury, be exposed to a pressure of more than three atmospheres.—2. That the use of the air bladder is not so much to regulate the specific gravity of the animals as to resist the varying force of the fluid column, and thus to protect the viscera and abdominal blood-vessels against excess of pressure.—3. (Though in this case the results are less striking) flat fish exhibit a limited capacity only for sustaining pressure. From these observations, Dr Williams inferred that the condition of pressure regulated the distribution of fishes in depth. Referring to the experimental researches of Prof. E. Forbes, he expressed his conviction that pressure would be found the most important element in the problem of submarine organic life. He observed that the lower animals evinced a tolerance of pressure peculiar to each species, and determining its zone of depth. The laws of oceanic temperature were next explained. It was experimentally demonstrated, that the expansion of sea-water is considerably greater than that of pure water, under equal increments of heat. It was, however, established by the acrometer, that density did not diminish in exact proportion with the increase of volume. It was argued, that this experiment went to account for the expansion of crystals by heat, as noticed by Mitscherlich; and that it also proved that in the case of two strata of water of dissimilar temperature overlying each other in the ocean, the tendency to intermixture by vertical molecular attraction was greater than would be the case if the sea consisted of distilled water. It was contended that it was in accordance with the principles developed in this experiment, that the warm water occupying the greatest depths in the sea (as discovered by Sir James Ross) rose to the surface and escaped under the form of vapour, which by diffusing warmth through the atmosphere mitigated the rigour of polar cold. Referring to the stratum of water of uniform warmth, observed by Sir J. Ross, the lecturer stated that he had ascertained, by experiment, that water acquires a considerable increase of temperature under great pressure, and that he thought that the temperature of the deep sea could only be satisfactorily accounted for by the condensation of bulk which the "air of water" underwent. The increase of temperature measured downwards from the stratum of uniform warmth to the sea bottom was noticed as proving that the latent heat of the dissolved air was rendered sensible as the pressure—that is, as the depth increased. Dr. Williams concluded by referring to the maximum density of water, the laws governing the solution of air in water, and by explaining the influence of those conditions on the existence and distribution of plants and animals in the sea.

The Timber Duties.—The following new and reduced prices on timber and wood goods came into operation on the 5th of April:—Timber or wood, not being deals, battens, boards, staves, handspikes, oars, lathwood, or other timber or wood, sawn, split, or otherwise dressed, except hewn, and not being timber otherwise charged with duty, the load, 15s.; deals, battens, boards, or other timber or wood, sawn or split, and not otherwise charged with duty, the load 1*l.* 1s.—or, in lieu of the duties imposed upon wood by the load, according to the cubic contents, the importer may have the option at the time of passing the first entry of entering battens, batten-ends, deals, deal-ends, and planks, by tale, if of and from foreign countries, according to their different dimensions and rates of duty, in which a considerable reduction is made, varying from one-fourth to a moiety of the rates of duty hitherto levied thereon; staves, the load of 50 cubic feet, 18s.; firewood, the fathom of 216 cubic feet, 6s.; handspikes, not exceeding 7 feet in length, the 120, 12s.; exceeding 7 feet in length, the 120, 1*l.* 4s.; knees, under 5 inches square, the 120, 6s.; 5 inches and under 8 inches square, the 120, 1*l.* 4s.; lathwood, the fathom of 216 cubic feet, 1*l.* 4s.; oars, the 120, 4*l.* 10s.; spars or poles, under 22 feet in length, and under 4 inches in diameter, the 120, 12s.; 22 feet in length and upwards, and under 4 inches in diameter, the 120, 1*l.* 4s.; spars of all lengths, 4, and under 6 inches in diameter, the 120, 2*l.* 8s.; spokes for wheels, not exceeding 2 feet in length, the 1,000, 1*l.* 4s.; exceeding 2 feet in length, the 1,000, 2*l.* 8s.; timber, planed, or otherwise dressed or prepared for use, and not particularly enumerated nor otherwise charged with duty, the cubic foot, 4d.; and further for every 100*l.* value, 10*l.*

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM MARCH 27, TO APRIL 20, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

Benjamin Grey Babington, of George-street, Hanover-square, Middlesex, M.D., and John Spurgin, of Guildford-street, Middlesex, M.D., for "Improvements in the manufacture of metallic pens."—Sealed March 27.

John Coates, of Seedley, Lancashire, calico printer, for "certain Improvements in machinery or apparatus for printing calicoes and other surfaces."—April 3.

Michael Joseph John Donlan, of Abbot's Bromley House, Staffordshire, Esq., for "Improved compounds or mixtures to be used for lubricating machinery."—April 4.

James Pilbrow, of Tottenham, Middlesex, engineer, for "certain Improvements in propelling upon railways and canals, and in the apparatus or machinery by which the same is to be accomplished."—April 4.

Thomas John Knowlys, of Hetham Tower, near Lancashire, and William Fillis, of Shirley, Hants, for "Improvements in generating, indicating, and applying heat."—April 5.

Joseph Foot, of Spital-square, Middlesex, for "Improvements in the manufacture of sleves."—April 6.

Eugene Ablon, of Panton-street, Haymarket, for "Improvements in increasing the draft in chimnies of locomotive and other engines."—April 8.

Thomas Gill and John Edgcumbe Gill, of Plymouth, manufacturers, for "Improvements in the manufacture of manures."—April 8.

Thomas Potts, of Birmingham, brass tube manufacturer, for "Improvements in the manufacture of tubular flues of locomotive and other steam boilers."—April 10.

Thomas Spencer, of Prescot, Lancashire, for "certain Improvements in machinery or apparatus for manufacturing pipes and tubes from clay or other plastic materials, part or parts of which improvements are applicable to the manufacture of hollow earthenware."—April 10.

James Derham, of Bradford, Yorkshire, manager, for "certain Improvements in machinery for carding, combing, preparing, and spinning cotton, wool, alpaca, mohair, flax, silk, and other fibrous materials."—April 10.

John Ecroyd, of Rochdale, Lancashire, machine maker, and John Eccles, of the same place, mechanic, for "certain Improvements in valves or plugs for the passage of water." April 10.

James Petrie, of Rochdale, Lancashire, engineer, for "certain Improvements in steam engines."—April 10.

John Longworth, of Newton Heath, Lancashire, for "certain Improvements in pickers for power looms."—April 10.

James Meacock, of Liverpool, gentleman, for "Improvements in preventing and extinguishing fire in vessels, warehouses, and other buildings, parts of which improvements are applicable to ventilation."—April 12.

John Masters, of Leicester, gentleman, for "Improvements in dress fastenings, and in attaching the same; and in articles made, wholly or in part, of certain flexible materials or fabrics."—April 12.

Henry Henson Henson, of Hampstead, Middlesex, gentleman, for "certain Improvements in railway carriages and wagons, and in vessels of capacity, employed in the storing and conveyance of explosive substances."—April 15.

Thomas Forsyth, of New North-road, Middlesex, engineer, for "Improvements in the manufacture of railway wheels."—April 15.

Charles Green and James Newman, manufacturers, of Birmingham, for "Improvements in the manufacture of a part or parts of railway wheels."—April 15.

Richard Madigan, of Haverstock-hill, Hampstead-road, Middlesex, civil engineer, and John Coope Haddan, of 14, Lincoln's inn-fields, Middlesex, civil engineer, for "Improvements in the manufacture of wheels for railways."—April 15.

Selah Hiler, of New York, in the United States of America, for "Improvements in the manufacture of stair rods."—April 15.

David Davies, of Wigmore-street, Cavendish-square, coachmaker, for "certain Improvements in the construction of the heads of open and close carriages."—April 15.

Charles Attwood, of Wolsingham, Durham, Esq., for a "certain Improvement or improvements in the manufacture of iron."—April 18.

John Britten, of Birmingham, machinist, for "certain Improvements in heating, lighting, ventilating, and closing and screwing the doors of apartments; also in lighting and ventilating carriages, parts of which improvements are applicable to other like purposes."—April 20.

Matthew Cochran, of High-street, Paisley, Renfrewshire, for "certain Improvements in the production of coloured patterns or designs on warps of carpets, velvets, or other textile materials, parts of which improvements are also applicable to the production of coloured patterns or designs on woven fabrics, or other planes."—April 20.

Samuel Clegg, of Regent's-square, Middlesex, engineer, for "Improvements in gas meters."—April 20.

John Strang Harradine, of Holywell-cum-Needingworth, Huntingdonshire, farmer, for "an Improved mode of fitting certain girths and straps."—April 20.

Henry Gilbert, of Saint Leonard's-on-Sea, Sussex, for "an Improved mode or improved modes of operating in dental surgery, and improved apparatus or instruments to be used therein."—April 20.

THE CONWAY TUBULAR BRIDGE.

(With Engravings, Plate VIII.)

The great engineering event for 1848 is the raising of the Conway Tubular Bridge, and which after so much fear and anxiety has been effected with great success. This work derives its importance not so much from its greatness, as from its opening the way for the adoption of a new system of bridge building, whereby the resources of engineering are very much extended. To build a bridge greater than those which have been made before, to make a railway longer than those which have yet been opened, or to construct a more powerful locomotive, is a great work; but it is of very much greater importance to execute something entirely new. The engineer who has constructed the greatest lighthouse or the greatest dock in his day, may be overcome by some one else, and then his claim is at an end; whereas the engineer who extends the resources of his art, has a clear and unique claim to distinction. Mr. Robert Stephenson has the merit of carrying out this system of tubular bridge building, and it will be a special event in his career, beyond the many works of constructive skill he has already produced. The success of the Conway bridge is none the less important, because it settles the practicability of that greater undertaking, the Menai Tubular Bridge. Thus progress in any one direction leads most certainly to greater exertion; and it is peculiarly necessary to give every encouragement to all attempts, which open a new career for the engineer, and give him greater means of exertion.

We are glad to learn that the trials hitherto made within the tube with locomotives have been successful, though we have not had the opportunity of personally investigating the real progress of the undertaking. We shall, however, watch it with interest and attention, to see how far its continued working justifies the opinion which has been entertained of its success: at the same time, we may say we do not participate in the fears which are entertained by some of our mathematical correspondents.

We have this month given engravings of the tube, and the lifting apparatus, and next month we propose to lay before our readers drawings of the ingenious Jacquard machinery invented by Messrs. Roberts, for punching the plates.

The construction when finished is to consist of two tubular bridges, formed of wrought-iron plates, each tube being for one line of rails. We shall now confine ourselves to the description of one of the tubes, which was fixed in its place in March last, and is shown in the accompanying engravings, Plate VIII.

Fig. 1 exhibits a transverse section of one of the tubes and the masonry of the pier, together with the lifting apparatus. Fig. 2 is a side elevation of 19 feet in length of the tube, resting on the masonry, and the lifting apparatus. Fig. 3 is a section through 12 feet in length of the tube, and section of the lifting apparatus. Fig. 4 is a plan of the top of the tube to the extent of 20 feet in length, and plan of the hydraulic press. Fig. 5 is a front view of one end of the suspension girder, and fig. 6 a side view.

The tube consists of a shell or external casing, *a*, *a*, of wrought-iron plates, from 4 to 8 feet long and 2 feet wide, by $\frac{1}{2}$-inch thick in the centre, and $\frac{5}{8}$ths of an inch thick towards the end of the tube, rivetted together to **T**-angle-iron ribs, placed on both sides of the joints, and angle-gussets at the feet of the ribs to stiffen them; a ceiling, composed of 8 cellular tubes *b*, each $20\frac{1}{4}$ inches wide, and 21 inches high; and a floor containing 6 cellular tubes *c*, $27\frac{1}{2}$ inches wide, and 21 inches high. The whole length of the tube is 412 feet, and 22 ft. $3\frac{1}{2}$ in. high at the ends, and 25 ft. 6 in. high in the centre, including the cellular tubes at top and bottom, running the whole length, and 14 feet wide to the outside of the side plates. The upper cells are formed of wrought-iron plates, $\frac{3}{4}$-inch thick in the middle, and $\frac{1}{2}$-inch thick towards the ends of the tube, put together with angle-iron in each angle of the cells; and over the upper joints is rivetted a slip of $\frac{1}{2}$-inch iron, $4\frac{1}{2}$ inches wide. The lower cells consist of $\frac{3}{4}$-inch iron plates for the divisions, and the top and bottom of two thicknesses of plates, each 12 feet long, 2 ft. 4 in. broad, and $\frac{1}{2}$-inch thick in the centre, and $\frac{1}{4}$-inch thick at the ends, and so arranged as to break joint; and a covering plate of $\frac{1}{2}$-inch iron, 3 feet long, is placed over every joint on the underside of the tube. The external casing is united to the top and bottom cells by angle-iron, on both the inside and outside of the tube, as shown in fig. 6.

The ends of the tube, where it rests on the masonry, are strengthened by cast-iron frames *d*, to the extent of 8 feet of the lower cells; 6 cast-iron transverse **I**-shaped girders *e*, on the floor; 6 similar girders *f*, above; and upright cast-iron stanchions *g*, on each side of the tube, to which are bolted the ends of the girders, top and bottom, and also the cross lifting girders *h*.

In order to allow of the free expansion and contraction of the tube, the ends rest on 24 pairs of iron rollers *i*, connected together by a wrought-iron frame, and placed between two cast-iron plates *j*, *k*, 12 feet long by 6 feet wide, and 4 inches thick. The lower plate is laid on a flooring of 3-inch planks *l*, bedded on the stonework; and the tube is also suspended to 6 cast-iron beams *m*, the ends resting on longitudinal bearers *n*, 12 feet long, with a circular groove on the underside, supported by 12 gun-metal balls *o*, 6 inches diameter, standing upon an iron bed *p*, and supported on the ends of the cast-iron bearers *q*. The tubes are suspended to the beam *m*, by wrought-iron bolts *r*, and spade-pieces rivetted on to the sides of the tube, as shown in figs. 5 and 6.

The lifting apparatus for raising this enormous weight was entrusted by Mr. Stephenson, to Messrs. Easton and Amos, engineers of the Grove, Southwark, to whom great credit is due for the very successful manner the tube was lifted. The machinery consisted of 2 steam-engines, erected in the recesses B, of the corresponding tube, one on each side of the river; and each engine has a horizontal cylinder, 17 inches diameter, and 16 inches stroke, with piston-rods working through stuffing-boxes at each end of the cylinder; each piston-rod has a cross-head, and gives motion by side-rods and cranks to two fly-wheels; and the ends of the two piston-rods work 2 forcing-pumps with plungers, $1\frac{1}{8}$ inch diameter, and 16 inches stroke. These pumps inject the water into the hydraulic press C, shown in the engraving, through the small tube (3).

The press was erected on a stage constructed above the level of the top of the tube, and consisted of two cross-girders of cast-iron, each in two heights D, D′, the lower one 4 feet high, and the upper one 2 ft. 6 in. high; the ends resting upon cast-iron bearers E, imbedded in the masonry of the piers. Upon the cross-girders was fixed the casing F, of the ram, which is 5 ft. 2 in. long, by 3 ft. 9 in. wide, cast with ribs; and on the top of the cylinder are fixed 2 vertical guide-rods G, G, 6 inches diameter, passing upwards through the cross-head of the ram, and a cast-iron girder H, nearly at the top of the tower, and 18 feet above the girders D′.

The press consists of a cylinder (1), firmly fixed in the casing, $37\frac{1}{2}$ inches diameter externally, and 20 inches internally; and the ram (2) $18\frac{3}{8}$ inches diameter, with a vacuity nearly $\frac{7}{8}$ of an inch all round, to receive the water injected from the pumps already described, through the tube (3), the orifice of which is $\frac{3}{8}$ of an inch diameter; this tube is furnished with a lever-valve close to the cylinder, for safety, in case the pipes should burst. In the event of such a casualty, by an ingenious contrivance the lever-valve would be instantly closed, and the weight supported by the water in the cylinder. On the top of the ram is a cross-head (4), of solid cast-iron, 9 ft. 10 in. long, 1 ft. 10 in. deep, and 2 ft. 4 in. thick, with two apertures, 2 ft. 1 in. long, by 1 ft. $1\frac{1}{2}$ in. wide, through which the lifting chains pass; and on the top of this cross-head are fixed two clipping vices or clams (5, 5,) each consisting of a pair of wrought-iron jaws, 3 feet long, 11 inches deep, and 6 inches thick, and a winch which turns a small pinion (6), that takes into two cog-wheels (7, 7′) fixed upon the heads of two horizontal screws (8, 8′ left and right handed) passing through nuts in the two jaws of the clams. Thus it will be perceived, that as the winch is turned, the jaws are made to open or close, for the purpose of clipping the heads of the lifting chains; below these clams are two others (9 9′), for clipping the heads of the lower links.

The two lifting chains consist of wrought-iron flat bars, in lengths of 6 feet from centre of bolt-eye to centre, and each bar is 7 inches wide and $1\frac{1}{8}$, $1\frac{1}{4}$, and $1\frac{1}{2}$ inch thick, with heads having shoulders fitted to the jaws of the clams. Each chain contained nine links of 8 and 9 bars alternately, besides the two lower links, each consisting of 5 and 4 bars. The heads of the first or upper links passed through the upper lifting clams, fixed on the top of the cross-head of the ram, and there secured by the jaws of the clams being screwed up taut; the second links passed through the lower clam, the jaws of which were left open, and the heads of the two lower links were made to abut against the underside of the lifting girders, *g*, *h*. When the pumps were set to work, the ram was lifted 6 feet, its full range; when it had attained this elevation the jaws of the lower clams (9, 9′), were screwed up close and clipped the heads of the third links (11), and there held the chain firm; the jaws of the upper clams were then opened, and the ram lowered down to its original position, when the bars of the top links (10) were removed. When this had been done, the jaws of the upper clams (5, 5′) were again brought under the heads of the second links, and screwed up taut, so as firmly to clip the shoulders of the links, the jaws of the lower vice (9, 9′) opened, and the ram was then set in motion to lift the tube another six feet, when the second links were removed as before described, and the operation repeated as above, until the tube had been lifted the height required, about 22 feet to 24 feet.

them, they require considerable modification in order to render them, or any one of them, generally applicable at the present day. After all, it may be questioned whether what looks so much like praiseworthy reserve, and scrupulous adherence to authentic models, does not proceed from motives that are not the most laudable. Merely to copy, saves such an infinity of study, thought, and trouble, as to render the copying system, in what calls itself a Fine Art, less of a mystery than it else would be. Architects—and I say it in sorrow—are not artists, except, perhaps, just here and there one exceptionally. The majority of the profession have nothing whatever of the feeling or spirit of artists in them. It is said that it takes nine tailors to make a man; I am sure it takes ninety-nine Architects to make an artist; for, as matters go, if we get one out of a hundred who answers to the latter character, we ought to be grateful. It will be said, perhaps, that the opportunities for showing artistic and original talent are so exceedingly few, that we ought not to judge of the ability *in posse* by the little ability which manifests itself *in esse*. Opportunities do occur, nevertheless, and what is the use we make of them? Why, to pirate, in the most unblushing manner, designs from Sansovino! It is true, Count D'Orsay makes a merit of such doings: what then?—he merely shows himself a priggish coxcomb. His countship's opinion may be very good authority for the cut of a coat, or other question in tailoring, but in Architecture not worth a straw; although it had, it seems, overbearing weight with the "Armoury and Knavery Club."

V. Beloved, but most unhappy Architecture, how art thou beset!—by the merest *apes* on one side, and the merest *parrots* on the other—creatures who merely repeat by rote what they have either heard from others, or got out of books, without bringing so much as a single idea of their own to incorporate itself with, or work upon it. So long as we merely listen to them in silence, they go on fluently and volubly enough. But once begin to cross-question them, and it is all up with them. Nothing then is left for them but to express astonishment at the ignorance which cannot perceive, or the impudence which presumes to throw doubt upon excellence that has all along been universally admitted. Anything like satisfactory reasons or intelligent reasoning, is not to be expected from people whose admiration is founded upon mere prejudice—upon authority, tradition, and conventionalism. Their criticism consists of nothing better than mere cant and parrot-like rote; and their dogmatism is in proportion to their shallowness. The most innocently-put WHY disturbs them,—upsets their criticism and their temper too. Albeit, anything but poetical themselves, they firmly maintain with the poet, that "Whatever *is*, is right;—in other words, everything is excellent for which due authority can be produced. And would they but be content to stop there, a good deal might be said in their excuse. Instead of that, however, they insist upon our believing that whatever is not—*i. e.* has not been done before, consequently derives no support from direct precedent for it, but must stand upon its own merits,—must of necessity be *wrong*, even though it should evidently be warranted both by analogy and common-sense. After all, there is a particle or two of shrewdness in the narrow-minded dulness of such persons: they have just discernment enough to be aware that they themselves depend entirely upon precedent, rote, and routine; and that by insisting upon others abiding by them likewise, they bring them down and keep them down to the level of their own intellect.

ARCHITECTURE AT THE ROYAL ACADEMY;

AND THE ARCHITECTURAL DRAWINGS AT THE EXHIBITION.

Most cheering and encouraging symptoms manifest themselves this year in the Architectural Room,—that is, supposing there be truth in the saying, that when things come to the worst they are sure to mend, for to that comfortable stage of *pessimity* are matters now come. Never was there before, within our recollection, so miserably poor an architectural "spread" at the Academy—such a beggarly and ill-arranged set-out. Even before we begin to look round, we perceive that one interesting class of architectural subjects are altogether missing. Either no architectural models were sent, or they were turned away; and incomprehensible as the last may be thought, it is quite as probable as the other case—at least to ourselves, because we happen to have seen some of the rejected designs,—designs, too, by those who have been exhibitors for several years past, and whose productions have usually obtained deserved commendation, both from ourselves and others. Their productions are now missing from the walls, and their names from the catalogue, which contains very few names indeed of any note in the architectural world; and what few there are, are not by any means *pluralist* exhibitors, they having contented themselves with sending no more than what just entitles them to an exhibitor's ticket. Possibly, however, we are here in error, and do them injustice, for though only one subject of theirs is to be found here, several may have been turned away: in fact, we know this to have been the case in one instance, and in that instance the drawing admitted is precisely the one which its author cared least of all about.

Knowing as much as we do, we cannot help suspecting that a great many more ugly revelations might be made, and a good deal brought to light that would accuse the Academy of most preposterous mismanagement in this department of its exhibitions, if of nothing worse. That architecture is there most unwelcome, there can be no doubt. That has been growing more and more evident for several years past. And to the chilling coldness with which it is regarded and treated by the general body of Academicians, may perhaps be attributed the *forbearance* of their architectural brethren, and the discountenancing, as far as in them lies, the practice of exhibiting architectural drawings at all. In the days of Sir John Soane, it used to be the custom for the Academy's Professor of Architecture—at least *he* made it such—not only to contribute, but to contribute each season, and to contribute abundantly. The present Professor, on the contrary, chooses to put himself upon the shelf, where he lies wedged in between Colonna, Vitruvius, and a good many other very mouldy and musty matters,—and wedged there so fast, that it seems he cannot get down for a moment to look at and protest against the outrageous doings in the architectural room.* Most enviable state of repose! it saves him from being horrified. Mr. Barry has of course other and far better "fish to fry." Sir Robert Smirke has been all along a nonentity in the Academy—save that he is its treasurer, and keeps a keen eye upon its "*shillings*." We should just as soon expect to find a design by one of the porters as by him. Mr. Hardwick and the new associate, Mr. Sydney Smirke, are the only architects connected with the Academy who condescend to let us see anything of theirs in the Exhibition.

Such being the case, we can forgive the editor of the *Art-Union* for so strongly objecting, as he lately did, to architects being elected into the Academy. Unless they enter it with the intention and full determination of really representing their own art there,—of upholding and promoting its interests, the "R.A." so acquired becomes more of a reproach to them than an honour. They only take upon themselves the ungenerous and odious part of the dog-in-the-manger; doing nothing themselves for either the Academy or for architecture, and excluding from the former those who deserve to be in it, because they would prove active and efficient members. There being so few architect-Academicians, is the very strongest reason possible why those few should exert themselves manfully, instead of sitting by most tamely, while architecture is all but actually kicked out. For it to be kicked out altogether would perhaps be less ignominious than to be treated as it is at present. Probably, next year the architectural drawings will be thrust aside into the Octagon-room—a hole, never intended, we presume, by Wilkins to form one of the exhibition rooms,—for this season most terrible inroad has been made by the painters upon the space hitherto allotted to such subjects, and to which they might be supposed to have acquired prescriptive right. The whole of the east-end of the room is now given up to oil-paintings,—not that we should at all complain of that, provided they were strictly architectural in subject, instead of being the refuse of the works of their kind in the Exhibition, with such charmingly namby-pamby titles as "The Pet," "Affection's First Offering," and others of the same "*missy*" and lack-a-daisical stamp. Had no architect-Academician courage to protest against such an invasion of the architectural territory on the walls? Was there not in the whole Academical conclave one single Abdiel

> "Faithful found
> Among the faithless, faithful only he
> Among the innumerable false, unmoved,
> Unshaken, unseduced, unterrified,
> His loyalty kept, his love, his zeal"?

That there was not even one such seems, for had such one there been, either his remonstrances would have had due effect, or he himself would have withdrawn, and renouncing the brummagem honour of R.A., would have escaped the ignominy of being confounded with the faithless,—for as matters stand, the being an

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* Wilkins, during his professorship at the Academy, exhibited only two small drawings, and those showed us his very worst work of all—Downing College, Cambridge. The present Professor has shown at least more discretion, for instead of exposing to criticism any architectural design of his own, he exhibited first what was only a medley conglomeration of Sir C. Wren's buildings; and next and lastly, merely a sculptural composition for a pediment in a building erected by another architect.

The power of the presses may be thus calculated: the area of the ram being equal to 337·64 circular inches, and the force acting upon the plunger equal to 2·14 tons per circular inch, the two being multiplied together give 722½ tons, which is the force of one of the presses, and of the two presses 1445 tons. The actual weight lifted was estimated at 1,300 tons. The quantity of water used for each press is about 66 gallons.

The tube was constructed on a platform erected on the shore of the river, close to where it was to cross; and when finished, six pontoons, something similar to the large coal lighters on the river Thames, were placed under the tube at low water, and which at high water lifted the tube off the piles upon which the stage was erected. It was then floated to its destination, and placed between the two towers, part of the masonry being left undone until the tube was put into its proper position, and as it was raised the masonry was built up under the tube. The time occupied in raising the tube and building up the masonry occupied four days; the actual space lifted per hour was 13 feet.

CANDIDUS'S NOTE-BOOK,
FASCICULUS LXXXII.

> "I must have liberty
> Withal, as large a charter as the winds,
> To blow on whom I please."

I. Surely there must be something wrong somewhere, when, notwithstanding all the numerous appliances and aids which Architectural study can now boast of, Architecture itself seems to have come to a dead stand. In the inability to get a step forwards, a merit is made of what an Irishman would call advancing backwards. To say nothing of the Institute, we have besides that a Royal Academy, which professes to extend its fostering protection to Architecture; also Architectural Societies, Decorative Art Societies, Schools of Design, and lastly, though not least, Professors of Architecture;—yet what is the art the better for them all? Can it do more than hash up again and again the cold remains of the banquets which it used to serve up in by-gone ages? If that "more" be not possible, there is little cause for us to vapour at the rate we do about Architecture as one of the Fine Arts. Either it has now lost, or is no longer permitted to exercise, the powers—to maintain the privileges of one. After *studying* all extant styles of the art, we are reduced to the mortifying conclusion, that we can do nothing whatever with any of them beyond copying, being ourselves wholly unable to catch and preserve the artistic spirit that pervades the best and most characteristic examples of the styles which we propose to ourselves as models. By dint of pains-taking industry, we can follow them tolerably well as far as they go; but where they stop short of what our actual purposes demand, we stop short too, and break down; and not only do they not go far enough for our present requirements, but they sometimes lead us astray, forcing more or less upon us that which is adopted merely because it is significant of the style, although at the very same time much that is incompatible with the style is tolerated on the score of necessity; so that, after all, it is generally suffered to be seen that there has been conflict between style and purpose. Without such thorough mastery over a style as can bend it, and render it quite plastic and tractable, it is hardly possible to produce more than either direct copies of former examples, or a sort of decent patchwork composed out of them. As one of the Fine Arts, Architecture might now very properly take for its motto, *Fui*:—"I was one once, but am so no longer."

II. It would not be amiss were some term introduced to distinguish those whom we now call Architects, from Builders, or else to distinguish the Artist or Fine-Art Architect from him whose practice and abilities do not extend beyond estimates, specifications, the preparing working-drawings, and the superintending the execution of buildings. Why not have the term house-architect, as well as house-painter, understanding by it those who make no pretensions, or whose works do not qualify them to make any to the more ambitious name of Architect in the sense of artist. At present, all who come under the somewhat vague denomination of Architects, assume to themselves the rank of artists—followers of what is by common assent and the laxity of language admitted to be a Fine Art. No doubt, such appellation (that of artist) is flattering enough; but then it carries with it a corresponding degree of responsibility. If it can be adequately supported, it is one of honour; if not, it becomes one of reproach and disgrace. In not being an artist there is no demerit; but the pretending to pass for, or at least rank as such, without possessing the least artistic talent, is surely not very many removes from quackery. If there can be no higher title than that of Architect for those—and they do not seem to be many—who follow their profession in the spirit of artists, a more modest designation would better become the majority, and would relieve them from the sneers and reproaches to which they now expose themselves.

III. The idea of erecting single colossal columns as monuments and architectural objects, was, no doubt, borrowed by the Romans from Egyptian obelisks. Inasmuch as they are both lofty, upright objects, exceedingly well calculated to show at a considerable distance, the column and obelisk agree; but they also differ quite as much, and the difference is decidedly in favour of Egytian taste. Whereas the obelisk is evidently a monument—a pillar erected to record some fact or facts, or dignify some locality, and is everyway fitted by its shape to stand as an insulated, independent monolith, the column plainly expresses itself to be a component member of a fabric; therefore taken by itself alone, meaningless,—in the condition of a verb without a noun, or a noun without a verb. Not only does the column suggest the idea of a superincumbent architrave, for supporting which it is intended,—but detached from it, acquires a *topheavy* and unstable look, the very reverse of that attending the *pyramidion* in which the obelisk is made to terminate, and which produces an obtuse apex, instead of the whole being prolonged to a sharp point, like a spire. Except its general proportions as to height, there is nothing that recommends a column for officiating in lieu of an obelisk. The so employing it manifests very great poverty of invention and barrenness of ideas,—the inability to devise new and more appropriate forms for new purposes. What is characteristic in the column, considered as an architectural member, destined to support either a horizontal entablature or an arch springing from its capital, ceases to have propriety or meaning in a pillar erected merely as either an ornamental object or a votive monument. Such monument may still be a pillar, but it should be one expressly adapted to its peculiar purpose; therefore, the less it resembles any of the so-called "orders," the better. In this respect, the Rostral column possesses a decided advantage: it shows itself most plainly to be neither more nor less than a *trophy pillar*. A column of that kind does not look like a fragment of a building. In a building, such form for the columns would be preposterous. To employ *Architectural* columns as detached monumental pillars, savours of pedantic and puerile conceit, akin to that which during the Elizabethan period fashioned chimney shafts into columns, designed, more orthodoxly than tastefully, according to some one of the "regular" orders.

IV. It is very possible for a man to have too much scholarship,—or to have it, if not too abundantly, too exclusively; so much of it, that he has no room in his head for any ideas of his own, nor any time for exercising his thinking faculties. In Architecture, scholarship is far more likely to prove injurious than at all profitable. While with the ignorant it may pass for deep study, it seldom amounts to more than idle display of learned frivolity; and is so far from really being study—that is, study to any purpose—that it is rather apt to check the latter, to become the substitute for it, and sometimes to lead astray into fancies as chimerical as they are extravagant. Infinitely better would it have been for Wilkins, if, instead of labouring to convince us that the Temple of Solomon was a building of the Grecian-Doric order, he had applied himself to more diligent and real artistic study at his own drawing-board. Pity that Solomon's temple, the tower of Babel, and the Parthenon too, including a good many other things besides, cannot be left at rest—or left to those who are more ambitious of displaying their pedantical erudition, than of contributing to, or in any way promoting artistic study—the very study of all others in which we are most grossly deficient. Did we find that archæological knowledge tends to enlarge the judgment, and to fertilise both talent and taste, it would deserve to be encouraged; it seems, however, to have quite a contrary effect,—to contract instead of at all expanding. Hence is it that copyism, which should be our shame, is made our pride; and much as we vapour about art—mere empty vapouring after all—we show that we have no longer any faith in it, but take it to be now actually paralyzed, and incapable of doing aught further than it already has done. To revert to a former style, for the purpose of *gradually* moulding it into one that shall be far more suitable to our present occasions and wants than the original one is, would be allowable enough. But no: that must not be done,—such mode of proceeding would be accounted downright heresy. It would be tantamount to admitting, that, excellent as former styles were for the times which produced architect and Royal Academician is very much like being a traitor. Nor is it to such alone that it is reproach that they should have allowed architecture to be reduced to the degrading position in which it is now at the only Exhibition open to it at all, for it very strongly reproaches the Institute of British Architects also, who, instead of contributing to the architectural department of the Exhibition, and of coming to its rescue in the hour of its imminent peril, content themselves with standing aloof in sulky dignity. That those who act the part of cyphers in the Institute, should not show themselves elsewhere to be other than cyphers, is not much matter for wonder,—perhaps even less for regret. But its stars—the luminaries who shine so brightly in Grosvenor-street,—can it be that their talent quite exhausts itself in talking, and evaporates ere it can give any manifestation of itself in Trafalgar-square? Half the business of the Institute seems to consist in voting thanks to, and complimenting each other; which, for any good that the rest of it does, may pass for the better half of it. In the meanwhile, both the Institute and the Academy seem alike to shut their eyes to some of the consequences of their *innocent* indolence. Although they are not, it would seem, directly responsible to any one for their doings or non-doings,—for their sins of commission or of omission,—it behoves them to pay some little respect to public opinion,—and to preserve if possible, decency of appearances. After long hovering upon the verge of it, the Academy has at last overstepped that line of discretion and safety. It has this season put the "last feather" upon the camel's back. The time for remonstrance has passed away, since remonstrance has been tried, and has proved fruitless, or worse than fruitless. What has hitherto been remonstrance, and perhaps unpalatably severe admonition, will now become unsparing objurgation. Unless the architects of this country be the meanest-spirited creatures conceivable, they will now break out into open rebellion against the Academy, and then, when *proximus ardet Ucelagon*, will the Institute be able to escape unsinged? There is, indeed, what it might make use of as a "fire-escape;" yet whether it has sagacity enough ever to avail itself of such means is to us very doubtful. The probability is, that it will prefer the fate of a martyr—prefer being *roasted* alive, to making the least effort that would break the spell of its present *vis inertiæ*. Let us hope then that, come what may, its charter is written upon asbestos. At least, let that Palladium be saved, if only to be deposited in the British Museum, where it may in time come to be looked upon with—veneration.

Those who imagine that we are now writing in mere reckless *gaieté de cœur*, are exceedingly mistaken. It is with feelings of sorrow, mingled with shame and indignation, that we pen what is likely enough to be set down for mere flippancy;—with sorrow for the contumely cast upon the art we love,—with shame for those who are themselves shameless—with indignation against those Judas-like friends of architecture, who betray it with their kisses. Good, easy creatures!—do they suppose that they are unnoted and unmarked by other eyes, merely because they choose to shut their own? To the public, all may seem calm,—and a desperately *dead* calm it is; but a speck has been seen in the sky, that announces a gathering tempest. What will come of it, should anything come of it at all, will be felt in due time; and then, perhaps, "*Sauve qui peut*" will be the cry. Of that, however, no more at present.

There are, as we have already said, no productions at the Academy this season, of that class which ought to make not the least figure of all in the Architectural Room—namely, models of buildings; although there is still admitted there the usual number of works that would be far more appropriately treated, either in the Miniature or the Sculpture Room. For aught we know, architectural models may have been offered and turned away. All we know is, that things there are of the kind—and very interesting things of the kind—which neither are nor ever have been exhibited. Regret, however, is greatly mitigated, and surprise almost entirely dissipated, when we call to mind the ungracious churlishness with which—judging from the awkward, huddled-up manner in which they are generally arranged,—models seem to have been admitted. Such exceedingly glaring mismanagement is visible at the first glance, that we cannot help imputing it to intention, and to the policy which worketh by cunning and stratagem. Hardly can we give the hangers credit for so much blundering stupidity as now shows itself more stronger than ever. Policy there must be in it, and its intention seems to be nothing less than gradually to work the expulsion of architecture from the Academy, at least from the exhibitions, by disgusting architects, and so deterring them from sending at all—which is all but completely effected already,—and by rendering the show of architectural drawings as unsatisfactory and uninteresting as possible, till they come to be looked upon by the public as mere filling-up rubbish, that has no right to be there.

Nor is it the "hanging" alone which is to be complained of, similar perverseness in selecting and admitting subjects. There are a great many things which, although architectural in subject, do not belong to the Architectural Room, inasmuch as they are not fresh *designs*, nor are the ideas they show those of their respective exhibitors. They are merely views and portraits of buildings, and for the most part of such as are already quite familiar to every architectural student. We do not go into that room to look at frames containing such stale matters as the Parthenon and other ragged ruins, whether Greek, Roman, or English; or at such rarities as our own City churches. If views or other copies are admissible at all, they ought at least to be confined to such as represent unedited subjects,—which, were they sought, might be found in abundance: were there no other, one there is which has never been touched by the pencil—viz., the colonnades in the court-yard of Burlington House. Or if enow of subjects are not to be found here at home, they are to be got at without going quite so far as Athens and Egypt, for they present themselves at Paris, Munich, Berlin,—almost at every step on the continent. Without going so far as to prohibit them altogether, there ought to be some sort of restriction with regard to what are merely topographical and architectural views. Some judgment might surely be exercised in determining their admissibility. Superior talent shown in execution might fairly enough be allowed to be passport for what possessed no great novelty of subject; but to find so many things as we do, that possess no redeeming qualities that might excuse the staleness or insipidity of their subjects—and some of them occupying far better places than original designs,—is not a little provoking.

That such evident mismanagement as declares itself in the Architectural Room, should be persisted in season after season, with a growing tendency to worse instead of at all to better, is to us nothing short of marvellous. The Academy—its architect-members included—seem not only to be utterly indifferent themselves to the architectural part of their exhibitions, but also to imagine that every one else is equally indifferent. Yet, surely complaints must from time to time have reached their ears. Their being disregarded is, perhaps, to be attributed to their having been uttered in too mild a tone; and if so, they ought now to be thundered forth so loudly, that the Academy cannot possibly pretend not to hear them,—and hearing them, cannot but pay some sort of decent attention to them.

After this unusually long proem—querulous also, we admit, though not without ample reason, and perhaps more energetic than polite in tone,—we proceed to say something of the few drawings of any mark in the present Exhibition. The hangers have taken care that we shall not gratify our curiosity by the very first subject whose title excites it—viz. (No. 1095), "Design for embellishing the new Coffee-room at the Carlton Club-house, carried out in Encaustic Colours," *F. Sang*. For aught that can be discerned of the encaustic embellishments, this drawing might nearly as well have been hung with its face to the wall, or at least turned topsy-turvy, as be placed where it is—immediately next to the ceiling. We remember being much gratified by three drawings of the hall, &c., of the Conservative Club-house, exhibited a season or two ago by the same artist; and which, for a wonder, were placed where they could be inspected. The drawing now *exhibited*,—exhibited at least in the catalogue, though put out of sight in the room,—is no doubt equally interesting. Not at all unreasonable is it to suppose that it shows improvement, rather than any falling-off, on the part of Mr. Sang. Subjects of that class are not so very numerous, that we can afford to be cheated out of the opportunity of examining them. Possibly, Mr. Sang himself may feel consoled by the honour of being an exhibitor; and by getting his ticket of admission—all that many of the exhibitors seem to care for; but we have nothing to console us for the provoking disappointment to which we have been subjected.

The next—(No. 1096), "Prize design for the proposed Army and Navy Club-house in Pall-Mall," *G. Tattersall*,—occupies a similarly lofty, though certainly not conspicuous station. Having seen it before, at the exhibition of the competition designs for that Club-house, we do not at all regret that it is placed where we cannot see it again; but we think that Mr. Tattersall himself must be anything but well pleased with the hangers for putting his "Prize Design" so far out of sight, and his other somewhat queerish design for the same building (No. 1229), in a much better situation,—we do not say the most advantageous one for it. As we expected, there are many other designs for the same Club-house, including the adopted one (No. 1187), by Messrs. Parnell and Smith. This was known to us before, a copy from the same drawing having been given in a contemporary publication, wherefore we would rather have found here something that would have enabled us to judge of the interior. By not doing so, we perhaps miss very little, for, from what has been said of it, the plan appears to be excessively common-place. There are about half-a-dozen other designs for the same Club-house; therefore, instead of being scattered about on the walls, and some of them put where they are scarcely visible, it would have been better to have collected them into a group. We should have preferred seeing here the respective sections, for those drawings were not exhibited at Lichfield House, although some of the plans convinced us that the sections belonging to them must have been more than usually interesting. Sections, however, are not at all in favour with the Academy;—are things by far too prosaic to be admitted into their Architectural Room. Isometrical perspectives of prisons are in their opinion more artistic drawings and dignified subjects than sections of even palatial club-houses. Such doggrel mode of drawing as isometrical perspective tolerated on the walls of a Royal Academy!

Designs for Railway Stations are quite as numerous, perhaps even more numerous, than those for the Club-house; and they may be allowed to show a good deal of variety, with a good deal of sameness,—variety, inasmuch as they conform to no generic character, but assume all sorts of masquerade, from the costume of almshouses to that of aristocratic mansions;—and sameness, inasmuch as they nearly all affect to look prodigiously "*olden-time-ish*" —a very great propriety, no doubt, when we consider how many centuries ago it is since railways were first established. A herald would trace them back to the Conquest, at least, and make out that they came over with the Normans. Sameness, too, there is with respect to paucity of ideas, and poverty of invention. If we consider them merely as drawings, showing imitations of the respective styles and classes of buildings, some there are well enough entitled to approbation, but hardly so as *designs* for a specific and wholly *un-precedented* purpose, and accordingly demanding to be invested with some sort of specific character.

(To be continued.)

ON ARCHITECTURE AND PAINTING,

ESPECIALLY IN RELATION TO THE ERECTION OF PROTESTANT CHURCHES.

Letters written from Italy, by W. M. L. DE WETTE, D.D., *Professor at Basle.*—[Abridged from the German.]

If one, who like myself, is merely an amateur of art, and quite a stranger to technicism,—ventures to lay down principles and give advice, he may be sure of encountering the prejudices of artists and critics by profession. If he, moreover, steps forth, with a certain independence of judgment, on an area where tradition and custom sway all minds—fearless of touching at some of the existing prejudices, his giving offence is unavoidable. Still, I shall make the venture, and my ignorance of technicism deters me the less, as I have found that technicists very often mistake the *true scope of art*, on account of their predilection for that sort of mastership—a prejudice, from which I, at least, am free. I may possibly be taunted with other prejudices and with one-sidedness; still, I hope to give some useful hints.

I begin with a few remarks on painting; and, without wishing to enter into a definition of what it *is*, or *ought* to be, it is certain that its destination is to convey representations and feelings to the mind. But all representations, be they what they may—either intuitions of the senses, or images of the fancy, or conceptions of the reason, or ideas of the mind,—consist of *two* elements; one suggested by *experience*, and another appertaining to the activity of the *mind*: one real-sensual, and one real-spiritual and primordial. In the intuition of senses, the first element preponderates so much, that we may be tempted to consider it the *only one;* but the more accurate observer will soon perceive that the mind has also its share in it. It is *it*, which impresses form to the matter of the senses—receiving that which it has viewed, within the pale of his other observations, and converting it into an intuition. The products of imagination may appear to a superficial observer as something *produced* by the mind, but the substance of it appertains entirely to the experience of senses; imagination having merely decomposed it, and combined it in another shape and way. Even the ideas of the mind (be it in art or otherwise) are no absolute produce of our thinking faculties; being merely deduced from experience.

Undoubtedly, the arts have risen from the imitation of nature, from the representation of the really existing—and even their present process and progress are the same. Thus, while conceding, that in any art-object so much of the *real* be existing, we may be induced to doubt how far *ideality* may enter therein at all. But if we take the difference between a picture and a daguerreotype, the case will become perfectly clear. In the former, that which occurs to the external eye piecemeal, must be seized by the mind and intellect as a whole—and put forward as a self-existing, independent object. For the first, besides nature, models, antiques, anatomy, &c., are used, all which will yield materials on which the artist can and may dwell; but imagination will supplant many of these helps, as we see in Raffaelle, who, after having devoted nearly his whole talent to painting, became the *completer* of the finest modern edifice in the world; we mean the dome of St. Peter —which will lead us to a more detailed inquiry on the art of the builder.

Architecture may be called the most difficult of arts, as it is a fact that its products have experienced the most opposite and most severe criticism. The reason for this might be found in architecture being *not sufficiently free*—being, as no other branch of art, tied up to a certain scope; and only after this is accomplished, the demands of the beautiful may and can be attended to. On the other hand, the freedom accorded to the architect is something very vague, as he cannot follow any prototypes, but (as in music) has only to be guided by the internal measure of mathematical intuition, or the judgment of proportion and æsthetics. This, however, can never afford such certain and stable rules as the other arts have deduced from the observation of nature, &c. Amongst the many styles of architecture are the Egyptian, the Greek, the Byzantine, the Moresque, and Gothic; and in *every one of them* architectural beauty can be achieved. In this incertitude of *legislation*, if we may so call it, the chance of falling into the arbitrary, burlesque, or absurd, is greater than in most other arts.

The surest way is—to start in architecture from the *scope given*, as the other fine arts start from observation of nature, which with all of them constitutes their store of reality *(Boden der Realität)*, and by which, after all, the character of the architectural style is determined. Because it is easy to conceive, that, for instance, the Grecian temple and the mediæval church are mostly shaped after the circumstances of *climate* and their respective *scope and usage*. To choose a style, not adapted to our wants, is an imitation bare of character—which, however, is frequently to be met with now-a-days. A similar tendency of imitation and dangling with the antique and the foreign, and a want of originality, pervades much of modern art, but nowhere more than in architecture, where it seems that all trace of inventiveness has exploded; still, this cannot be the case, as our most modern times must have and have wants of their own. This, most assuredly, is the case with Protestant (evangelic) church architecture, to which the particular character of our worship prescribes especial rules, which, however, have not yet been attended to. If we refer the word "Church" to the original *Ecclesia*—a congregation, the importance of the sermon becomes with us paramount; far more so than it ever had been with the old (Papal) church. Taking the sermon as the chief feature of our worship—the scope and aim of a Protestant church can easily be explained. For the sake that the aim of a sermon (like any other speech) be accomplished, the orator must not only be heard, but *seen by all*. This applies with equal force to the orator himself, as he requires to have all his hearers within the reach of his eye, to enter with them into a *living contact*, which some may call mesmeric. For this aim, the churches, as they have come down to us from Catholicism, are not appropriate. In a Basilica or Gothic church, with one or two lateral naves and a choir, the pulpit *cannot* be conveniently placed, nor the orator heard; which is the reason, that in Italy a large cover or carpet is spread over the pulpit and main nave on festival occasions. The new spirit of Christianity could not re-model everything at once, and especially in the department of architecture: it adapted itself to the already existing. Roman Basilicas were converted into Christian churches, and retained by custom their mis-appropriate form.

That which serves the purpose of the sermon is also in accordance with the spirit of a truly evangelic worship—which is, that the congregation be *conscious* of their communion and community during the time of divine service; and for this aim, not only the preacher, but *every one* attending ought to see *all*, for the sake of arriving at the conviction that they are a *community!* But the life of community, which existed in such eminence amongst the first Christians, exploded gradually, as priesthood became paramount, until all idea of a congregation (community) degenerated into that of a complete priest-hierarchy. In Catholic churches, such things as congregations, properly speaking, never exist; but one portion attends to the mass, others pray at the several altars, others come to and fro; and even the preacher has only a portion of the people around him. The priesthood, alone, form a compact, uniform body, which, however secludes itself in the choir, taken up with particular functions. In this part of Catholic churches, as well as in their whole structure, the want of community is apparent; and if it had been as easy to erect new churches as to change a creed, Protestants ought never have used Catholic churches for their worship. Necessity, however, prevailed, and some of these older structures deserved preservation on account of their beauty. Still, it is a dereliction of duty, if new Protestant churches are built in the form of Basilicas or the old cross-shape.

It is not our province to make any *specific proposals* for the erection of Protestant churches; still, it is the duty of our architects to search after, and to discover that form—provided all power of invention has not left our age! So much we may say, that, according to our foregoing reasoning, this form ought to approach the *circular* or *elliptic*. The round form may possess some disadvantages in an acoustic point of view, but we do not doubt that they can be overcome by study and research.

While the architect attends to the scope of a building, he has, especially in public buildings, also to take care of its *character of beauty*. All nations have imparted to their sacred edifices, *beauty*, *character*, and *sublimity*; and Protestantism, if it comprehend the vocation of religion, cannot neglect the above requisites of sacred buildings. The aim of worship requires an adequate and worthy expansion of space. The sentiments of holy earnest, of pious peace and adoration, will receive much additional strength from a worthy and adorned locality.

It has often been asked, *what* constitutes the beauty of an edifice? Surely *not* the costly, glittering materials which Catholicism has squandered on them in Italy, partly from heathenish spoils transferred there. Another—and we say a *superior* mind reflects from the Gothic churches of the north of Europe. The temples of Pæstum, superior to *all* the ruins of Rome, are of travertine; which coarse material, however, is deified, as it were, by the exquisite form and proportion. It is form which constitutes beauty—which, after all, is but form perfect. Both appertain to the mind; mind creates form, and then reflects, with ecstacy, on his own work—the laws of its own being brought to manifestation—beauty.

Certainly, before an intuitive observation, the distinctions of material and form vanish. Certainly, marble is more pleasing to the eye than gritstone, on account of its finer component parts and colour, which both are forms. The architect cannot disdain the nobler material on this account, as well as for its greater plasticity and adaptation to elaborate workmanship. The custom to construct public, especially sacred, buildings of noble materials, and to adorn them costly and splendidly, is most ancient, and based on a true sentiment of our mind. Everything rests here on certain proportions and measures; as also the connection between material and form obeys the same laws. Even a building, or parts thereof, the interior of a church or hall, may become heavy and cumbersome by being overloaded with ornaments, on account of form being here obscured and borne down by material. The latter is the case with the Milan Domo, the outside of which is too rich in ornament, while the inside is grand and sublime.

The beautiful in architecture can be divided into several radii which we shall attempt to enumerate, in accordance with the relation of their usefulness and adaptation. The latter may be raised to beauty, or even sublimity—if the size by far outstrips the bounds of absolute necessity. The scope of religious assemblages requires but a limited height of space; but the tendency of art soars *beyond* that, and attempts to expand, conjointly with material space, our feelings and sentiments. Another way of achieving beauty is to employ greater means and aids than are absolutely necessary. The building may, for instance, require pillars for its support; but art takes hold of this want, and increases their number to the greatest amount compatible with true proportion. Finally, the scantiness and stern simplicity of the straight line may be increased by lines arcuated and wavy But to all this must be added *something inexpressible* by mere words—which, however, may be best termed harmony, concordance, and unity of conception. Size and height—fulness and diversity, the free scope of form, must all combine towards unity; and naught to appear as superfluous, isolated, or preponderant. By the observation and comparison of a number of buildings, and by abstracting laws therefrom, certain rules of proportion (numerical, geometric, and others) have been arrived at; to which *fanciless* architects are accustomed to adhere slavishly. But the true laws of construction lie in the impression a building will produce, and which the real artist will know how to anticipate by some sort of internal *art-intuition;* this inward conception precedes all sketches on paper or parchment.

Let us now endeavour to sketch that impression, which a Protestant (evangelic) house of God has to produce. The usual classification of the Greek, Roman, and Gothic may serve as a starting point. The Grecian temple is conspicuous for its moderate compass, and the rectilinear form of construction. It is altogether the type of the polytheistic mind of their builders, unable to seize the greatness of *One-God*. Still, it produces the effect of a clear, serene majesty; and further, the Doric may be said to be more stern than the others. It seems to us the fundamental fault of Michael Angelo, and other architects, who have taken the *antique* for their prototype, to *transfer* the Grecian-Roman style into Christian churches. The Doric colonnade would have been, no doubt, the most adapted to Christian worship; but, so far as we know, that style has been used but rarely; substituting for it the more slender, serene—nay, lascivious Ionian and Corinthian orders, where, at times, colossal dimensions were introduced to palliate the inconvenience thus arising. But already the Byzantine or Romanic style of architecture had changed the Greek into one more appropriate to the Christian mind, by adopting greater height—thereby, expanding the column to gigantic proportions, and substituting the round arch for straight lines. For the external ornament of churches, or even the upper parts of their interior, this style used thin, short columns with arches, over which a profusion of sculptural and mosaic ornament is spread. The too stern character of the *ensemble* is thereby modified, and amenity added to sublimity: just the same as the worship of the true Christian is tempered by mildness and love.

Gothic church architecture has, however, achieved the greatest sublimity of religious sentiment, by its pointed vaults; but here, also, a richness of ornamentation unites the serene and lovely Peculiar to this style of architecture, is the mysterious and awe-inspiring, which arises partly in the structural proportions and forms, and partly in the painted windows, spreading a mystic *chiaro-scuro* over the whole expanse of space. If we assume, in fine, that Protestantism has developed faith and adoration to its greatest height and freedom, there can be no doubt that the character of sublimity,—viz., the pointed arch style, has to be chiefly adopted. It can hardly be doubted, that the adaptation of this style will permit the carrying out the above-stated requisites of Protestant worship, consequent on its very essence and mind—yet, we acknowledge that a sacred edifice thus constructed will be *much different* from a Gothic cathedral. It may be thought, that the character of the structure might be somewhat modified by a greater clearness and serenity of its plan and conception. Protestantism educates towards self-thought and clear ideas; henceforth, even its external manifestations must seek for clearness and light. As the congregation has to see *itself*, as bibles and books are to be oftener referred to than with Catholics—stained windows will not be adapted,—the more so, as the frescoes proposed by us as a chief ornament for the walls of the interior, would be quite confused and obliterated thereby.

Of these we shall speak in conclusion. In this respect, also, a certain chaste economy, if we may say so, is to be recommended. In Catholic churches, not rarely a sensual profusion of marble and gold is to be regretted, and at the same time, walls and ceilings are overloaded with paintings. This medley, however, of a motley *coloration*, makes an especially confusing impression on the beholder. Against the painting of ceilings we must pronounce most strenuously, as even with the best light it is impossible to view them with the requisite quiet and ease; the outward quiet, however, of the beholder being the necessary condition of the inner satisfaction, which is the aim of all art. At times, moreover, the light for such ceiling-paintings is quite a wrong one, as is the case in the dome of Parma. How much of art and means have been wasted in ceilings, and how slight has been the the result! On ceilings, art should not effect but an adequate and harmonious display of colour; at the utmost, arabesques or facettes are to be used, as is the case in some of the churches of upper Italy. Figures and groups however, ought to be placed at a convenient distance, and in no distorted positions or fore-shortening. If our idea of a communion in Protestant congregations be assented to, pictures ought to be used but rarely, and of a simple, but grand character; else they would distract the attention of the people. Large historical compositions attract too much attention; but figures or heads of great and pious personages will be more appropriate, besides requiring only a limited space.

If we endeavour to *combine* the purport of our foregoing observations—we have to repeat, that painting has to receive a real element and *substratum*; architecture, to manifest the scope of adaptation; all pervaded by an ideality, which appertains to the subject—an intimate connection (permeation) of the real and ideal. We have to insist on compositions, clear, free, and well-combined: in fine, the preponderance of the art-scope;—viz., to bring the beautiful and sublime into external existence, and thereby to awaken art-feelings—viz., feelings of serenity, elevation, and contentment. We cannot forego to express our opinion, that great *religious* buildings can and will never be conceived but by men possessing those feelings in an eminent degree. The complication of estimates and business can hardly be avoided now-a-days; but composition and inspiration can alone produce huge structures, worthy and able to inspire the *people*—a sentiment they cannot any longer be kept without.

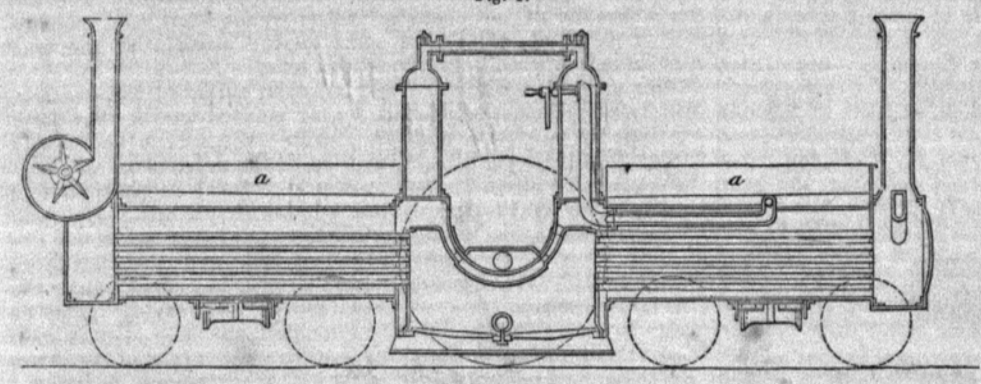
J. L——Y.

REGISTER OF NEW PATENTS.

LOCOMOTIVE ENGINES AND CARRIAGES.

James Pearson, of New North-terrace, Saint David's, Exeter, for "*certain Improvements in locomotive engines and carriages.*" —Granted October 7, 1847; Enrolled April 7, 1848.

Fig. 1.



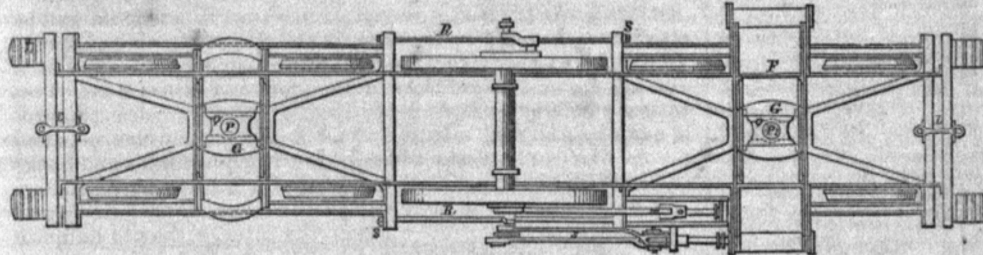


Fig. 2.

This invention applies to several parts of locomotive-engines and carriages. One part consists in the form of the boiler, which is made with the fire-box in the middle part of the boiler, instead of being at one end. The general outline of the boiler is such as would be formed if two locomotive boilers of the ordinary construction were placed end to end with their two fire-boxes about four or five feet apart, and then the parts of the fire-boxes below the fire-door were joined together by an additional piece of fire-box, so as to connect the two ends together into one large fire-box in the middle of the boiler with a chimney at each end (fig. 1); or the boilers may be entirely separate and distinct, that is to say, having two entirely separate and distinct fire-boxes butting against one another, and having water and steam communications common to both, but which may be shut off from either boiler at pleasure. The axle of the driving-wheels is placed in the middle of the boiler, above part of the fire-box and below the foot-plate, so that any desired amount of weight of the engine may be brought upon the driving-wheels, and at the same time the centre of gravity may be kept very low. The axles of the trailing-wheels are placed below the cylindrical part of the boiler, and two pairs of these are placed in one swivel-frame at one end, and two pairs in a similar frame at the other end. The two frames are coupled together by two tension-rods R, (fig. 2). Near the ends of these rods R, are placed springs S, made of vulcanised india-rubber, and beyond these springs are nuts to confine them. The use of these springs is to allow each swivel-frame to adjust itself to any inequality of the road, and to bring it back to the straight position when the road is even. The swivel centre-pin P, is fitted into a socket Q, which is allowed to slide a little endways in guides G, to allow for expansion and irregularities, and the holes in the links L, are made oblong for the same reason, and that the links may pull instead of pushing. The boiler and engines are supported on a long upper frame F, which is attached to the lower swivel-frames by the two centre-pins P, P, and by the links L, at the end of the engine. The whole forming one compound swivel-frame.

The coke-box *a*, *a*, is placed on the top of the boiler. The water-tank may be on a separate tender, or may be placed between the coke-box and the boiler, or attached in any other convenient way. The two steam-heads may be connected at such a height as is convenient to leave head-room for the engine-man.

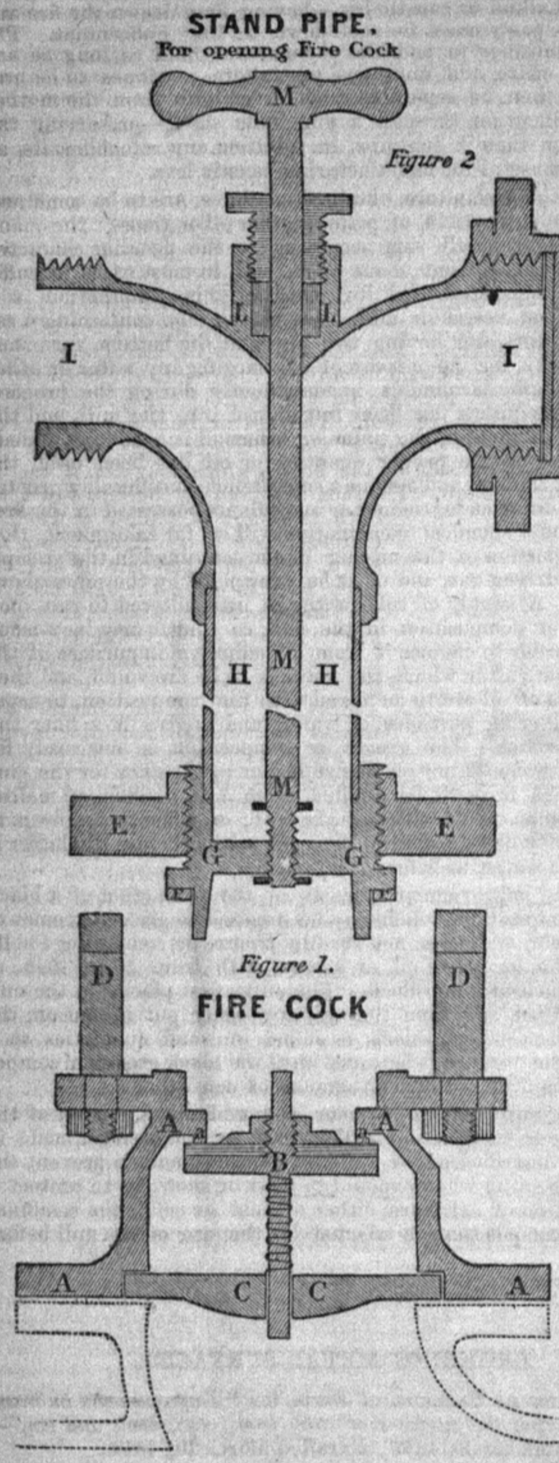
Another part of the invention consists in the application of an exhausting-fan in the smoke-box to draw the heated air through the tubes of the boiler, and to discharge it either up the chimney, as shown in fig. 1, or, if preferred, it may be again returned as hot blast into the furnace. This fan will allow the use of waste steam-pipes of a large size direct from the cylinder into the open air, and so avoid the great pressure on the back of the piston when the ordinary blast-pipes are used. The fan or fans may be driven by bands from pulleys on any of the wheels or axles, or by a small engine fixed on the side of the boiler, which may also if required work the feed pumps. The fans if driven by pulleys must each have two pairs of pulleys and suitable clutches, one pair driven by an open strap, and the other pair by a crossed strap, so as to drive the fans always in the same direction, whichever way the engine may be going. The clutch-gear may be attached to the engine reversing-gear if required.

Another part of the improvements relates to coupled locomotive engines, in which arrangement the compound swivel-frame is adopted. There are other improvements mentioned, but they are merely variations of those already explained. The patentee does not claim the invention of swivel or "bogie" frames generally, but his claims are, the compound swivel-frame, with coupling-rod, provided with elastic springs or cushions, and the various attachments to the upper frame; the form of boiler; the use of exhausting-fans for obtaining strong draught; and the compound swivel-frame, connected by rods with elastic cushions, and provided with guides and end links, as above described.

CHRIMES' PATENT FIRE-COCK.

The accompanying engraving (one-third the full size) of a fire-cock or valve, is a substitute for the ineffective wood plug, now in use in service mains. When under constant high-pressure, it forms a substitute for fire-engines, as in cases of fire it can be brought into almost instant operation, without that loss of time and waste of water which the use of the wood plug involves. It can be also expeditiously, cheaply, and most effectually applied to the watering and thorough cleansing of streets, courts, alleys, public buildings, windows, &c.; and in railway stations, to almost every use for which a free supply of water is required, including supplying engine-tenders, cleansing carriages; and it is also adapted for watering gardens and pleasure-grounds, and by the application of suitable outlets, for syringing fruit-trees. It is especially adapted for high-pressure supplies, as from the circumstance of the valve part of it being closed by the pressure of the water, the higher such pressure becomes, the more is the tightness of the valve secured, and effectual safety from leakage insured. One great advantage it has over the ordinary fire-plug is, that the stand-pipe with the hose can be placed on to the valve without the escape of any water, although the mains may be charged with water at a high pressure.

By the present system, unless a cock is attached to the branch of a fire-plug, a great loss of time unavoidably occurs in removing the wood plug, as the water has to be turned off the main pipe before the plug can be removed, and to be turned on again after it has been removed, to say nothing of the delay and difficulty which often occurs before it can be removed at all.



Description.—The Patent Fire-cock consists of a cast-iron boss, A, with aperture of such size as may be required, and flange for connecting it with a corresponding flange on branch from main pipe, as represented by dotted lines under fig. 1—the upper inner edge, *a*, of the boss being raised and faced, forms a seat for the loose valve, B, covered with leather, the spindle of which works in a brass bridge, C, and when not in use, is always closed. To the boss are attached wrought-iron inverted L-shaped lugs, D, to which the stand-pipe, when brought into use, is secured.

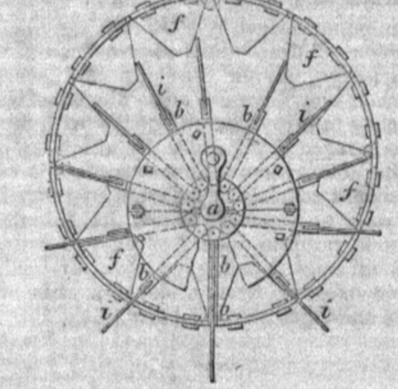
This stand-pipe consists of a copper or iron tube H, with two branches on the upper part I, furnished with screwed ends for attaching the hose; one or both of the orifices are also furnished with a brass screw-cap K. At the connection of the diverging pipes is a stuffing-box L, and at the bottom part of the stand-pipe there is a brass male-screw G, with leather washer F, working through a brass female-screwed collar E. This collar has projecting lugs, which passing under lugs D of the fire-cock, firmly secure the lug together, and form a connection of the stand-pipe with the fire-cock, perfectly water-tight.

Passing down the stand-pipe, through the stuffing-box L, is a wrought-iron rod, with brass crutch-handle at top, and a male-screw at bottom, working through a brass female-screw in the bridge G. By turning the crutch-handle M, the rod gradually presses down the valve B, of the fire-cock, and allows the water to escape all round the valve and up the stand-pipe; and at the same time by the gradual opening of the valve by the aid of the rod and screw, the flow of water is controlled, and concussion in the pipes prevented; while at the same time the sudden strain on the leather, or other hose which may be attached, is, to a very great extent, diminished.

PADDLE-WHEELS.

Thomas Hunt Barber, of King-street, Cheapside, London, gentleman, for "*Improvements in machinery for propelling vessels.*"—Granted October 7, 1847; Enrolled April 7, 1848.

This invention consists of an arrangement or combination of parts into paddle-wheels for propelling vessels. The external case of the wheel is a cylinder, which is fixed to and revolves with the driving-axle; and the floats are so arranged within the cylinder, as to be projected outwards when required to act, and are again withdrawn into the cylinder as they go out of action; such construction of paddle-wheel allowing it to be wholly immersed in the water. To govern the action of the floats, the patentee prefers to use a cranked axis, one end of which enters into the main or driving axle. On to the main-axle is placed a boss, to which arms are attached, for holding firmly the floats. The annexed diagram, which is a side-section of the paddle, will explain the manner in which the floats are intended to act. The cylinder *b*, *b*, has as many slits or openings through it as there are floats to the wheel; and within the cylinder are angular hollow vessels *f*, *f*, which give buoyancy to the wheel, and also serve for the purpose of offering inclined guiding surfaces to the floats as they are moved outwards. The arms *h*, *h*, are attached by pin-joints to the boss or collar on the crank axis; and to the ends of the arms the floats are to be fixed. The floats *i*, *i*, *i*, are represented to be in action, whilst the others are drawn within the cylinder. The patentee says, that although he prefers to use a cranked axis for governing the action of the floats or paddles, it will be evident to an engineer that an eccentric might be substituted and produce a like result; and it will also be evident that in place of having the floats or paddles whereon are arms or spokes governed or controlled by a crank or eccentric axis, the case *b*, might revolve on and be governed by fixed eccentrics one on either side. In such case there would be a fixed axis between the eccentric bearings of the case *b*. The nave having the arms of the floats or paddles would revolve freely on the fixed axis between the fixed eccentrics, and the case *b* would receive motion by a cog-wheel affixed thereto driven by another cog-wheel actuated by the engine, or in any convenient manner.



What the patentee claims in this invention are, the modes of constructing paddle-wheels whereby floats, or paddles, or arms are combined with a case *b*, such floats on the case being governed by a crank or eccentrics.

RAILWAY CARRIAGES.

Thomas Dunn, of Windsor-bridge Iron Works, Manchester, for "*Improvements in railway wheels, jacks, &c.*"—Granted November 2, 1847; Enrolled May 2, 1848.

This patent comprises several objects connected with railway locomotion. Mr. Dunn first describes several improvements in the construction of wheels. One of the principal is the easy removal and replacement of the tyre upon the wheel when it has become worn. This he effects in several ways. His first method consists in having the nave, arms, and an inner tyre cast in one piece, upon which the outer tyre is bolted by means of a flange, which projects inwards a few inches beyond the inner surface of the tyre. The joint between these two pieces, out of which the wheel is formed, is packed with gutta percha or some other elastic substance. A second method consists in having the nave of the wheel cast with mortices in it for the reception of wooden arms or spokes, and in afterwards fixing the tyre to the nave, by bolts passing down through the middle of the spokes. According to a third method, that part of the wheel which is occupied by the arms is entirely filled in with segments of wood, between which segments there are driven wedges of either wood or iron, so that the wheel is almost entirely solid. The tyre is attached to the nave by bolts, as in the former instance.

The patentee makes his axles of wood and iron, the wood forming an internal solid core, with an outer covering of iron. He also makes axles of several pieces, by having the naves truly bored out, and driving into them a short axle, or rather part of an axle, which is formed on the outside of the wheel, into the journal or bearing, and on the inside projects only a few inches, leaving sufficient strength of material to pass a cotter through to retain the axle in the nave. The two wheels are then connected by rods of iron, which have collars formed upon them near to their ends. The portions beyond the collars are passed through holes formed in the naves of the wheels, and have screws upon their outer ends, so that the wheels are, in a measure, devoid of axles—the connection between them being formed by the rods.

The second portion of Mr. Dunn's improvements relates to the construction of jacks for moving carriages and locomotives on to the line of rails when they have got off. The chief feature of this improvement consists in providing the jacks with four small friction-rollers at the bottom of the pillar, by which the jack, with its load, is easily made to run upon a smooth surface in any direction.

A third improvement consists of a means of removing carriages from one line of rails to another, which the patentee effects by means of a low truck, running upon a set of cross rails. A portion of the main lines of rails is made to form an inclined plane at pleasure, by means of cams fixed under the rails, whereby he is enabled to run the carriages on to the low truck.

LUBRICATING COMPOSITION.

Thomas Denne, of Bermondsey, Surrey, strap manufacturer, for "*Improvements in the manufacture of grease or compositions for atmospheric pipes, and for lubricating the axles and moving parts of machinery.*"—Granted April 27; Enrolled October 27, 1847. [Reported in *Newton's London Journal.*]

The improvements consist, first, in preparing a lubricating composition by combining oil, or tallow or other grease, with certain light, soft, white, and unctuous precipitates or bodies, insoluble in water (so as to be incapable of being used as detergents), and obtainable in the manner hereafter described; secondly, in preparing a lubricating composition by combining oil, or tallow, or other grease, with vegetable black or with lamp-black; and thirdly, in mixing the compositions, prepared according to the first and second improvements, in such proportions as may be desirable, in order to render the same more suitable than when used alone for the lubricating purposes above mentioned.

The mode of carrying out the first improvement is as follows:—The patentee introduces into a vessel or tank such a quantity of *liquor calcis*, or of a saturated or other solution of sulphate of magnesia, or of sulphate of magnesia and ammonia, as he considers will be sufficient for the quantity of composition required to be prepared; he then gradually pours into and mixes with the same a strong solution of such of the vegetable or animal oils as are most suitable for the purpose, and which have been rendered miscible in water by boiling the same with alkali or caustic ley; or, instead of the solution just mentioned, he employs a strong solution of either the soft or hard soap of commerce; or he introduces the *liquor calcis*, or the solution of sulphate of magnesia, or of sulphate of magnesia and ammonia, into the pasty and saponaceous fluid, obtained by boiling either oil, or tallow or other grease, with alkali or caustic ley,—having first drawn the fire and allowed the pasty mass to cool down to 100° Fahrenheit. The patentee continues to add the saponaceous fluid so long as any light, soft, white, and unctuous precipitate continues to be produced; and then he separates such precipitate from the mother liquor, by filtration through a fine linen sieve,—preserving the mother liquor when it contains, in solution, any valuable salts, so as to make it useful for manufacturing caustic leys.

112 lb. of the precipitate, obtained as above, are to be combined with from 40 lb. to 112 lb. of palm or other oil or grease: the quantity of oil required will vary according to the peculiar character of the oil employed; but about 56 lb. will, in most cases, be sufficient. The apparatus used for effecting this combination is a cylindrical iron vessel or mill, open at the top, containing a revolving agitator, and having two pipes at the bottom, furnished with stop-cocks, for the purpose of discharging any water or other fluid that might accumulate inconveniently during the process. After the precipitate has been introduced into the mill, and the agitator set in motion, the palm or other oil is gradually added; then, as soon as the proper quantity of oil has been used, the mixture will thicken and assume a consistence considerably greater than the oil or other ingredient or ingredients possessed in the first instance; and a chemical combination will so far take place, that the greater portion of the mother liquor contained in the precipitate will be driven out, and must be drawn off by the pipes above mentioned. A supply of cold water is next allowed to run upon the grease or composition in the mill, so that it may be washed therein, in order to cleanse it from all adhesive impurities of the mother liquor; after which, the water is to be drawn off, and then a few pounds of oil are to be mixed with the composition, to separate any adhering particles of water, and to give it a finer and better appearance. The grease or composition is now ready for use; but if it should not possess sufficient consistence for the purpose to which it is to be applied, from 5 lb. to 28 lb. of melted tallow should be mixed with it in the mill; or, when the tallow is to be used, it may be mixed with the composition before the latter is washed with water, as before mentioned.

The second improvement consists in the production of a black grease or composition, which may be exposed to great extremes of heat and cold, and does not readily freeze, by combining 160 lb. of palm, olive, or other oil, or grease, with from 10 to 40 lb. of vegetable black or lamp-black. The oil is first placed in the mill before described, and then the agitator being put in motion, the vegetable black or lamp-black is added in small quantities at a time; and the mixture is agitated until the black grease or composition has acquired a sufficient amount of consistence.

The third improvement consists in combining a portion of the black grease or composition with grease or composition made in the manner described under the first improvement, to prevent the same from freezing when exposed to frost or snow, or to protect it from the action of extremes, either of heat or cold: the combination of the compositions is effected by the use of the mill before described.

BRONZING METAL SURFACES.

Charles de la Salzede, of Paris, for "*Improvements in brassing and bronzing the surfaces of steel, iron, zinc, lead, and tin.*"—Granted September 30, 1847; Enrolled March 30, 1848.

The improvements relate to coating steel, iron, zinc, lead, and tin, with brass and bronze. For the purpose of coating metal with brass, a bath is prepared, composed of the following ingredients:—5,000 parts by weight of distilled water, 610 parts of sub-carbonate of potash, 25 parts of chloride of copper, 48 parts of sulphate of zinc, 305 parts of azotate of ammonia, and 12 parts of cyanide of potassium. The cyanide of potassium is dissolved in a small portion (about 120 parts) of the cold distilled water; at the same time, the sub-carbonate of potash, chloride of copper, and sulphate of zinc, are introduced into the remaining portion of distilled water (contained in a separate vessel, and having its temperature increased from 144° to 172° Fahrenheit, to facilitate the dissolution of these matters); and when they are perfectly dissolved, and the solution has become cool, the azotate of ammonia is added. After the solution has been shaken for a long time, it is allowed to stand for 24 hours; it is then decanted with a syphon, and the solution of cyanide of potassium (which should be limpid) is added thereto. If the solution thus prepared be submitted for about five hours to the action of a volatic battery with a rapid current (such as Bunsen's, Grove's, or Daniel's battery), and at a mean temperature of 77° Fahrenheit, it will deposit a coat of yellow copper, or brass, on the metal article immersed therein. The process may be performed in vessels of porcelain, china, glass, or wood (which may be lined with bitumen, or any isolating resinous matter); and the vessels are preferred to be of a rectangular shape.

If the articles are to be coated with bronze, 25 parts of chloride of tin are to be substituted for the above-mentioned 48 parts of sulphate of zinc; the proportion of chloride of copper is to be increased from 25 parts to 48; and a plate of bronze is to be used as the electrode: in other respects the bath is prepared with the same ingredients, in the proportions above stated, and the process is conducted in the manner before described.

A bath, for coating articles with brass, is prepared, by dissolving 500 parts of sub-carbonate of potash, 15 parts of chloride of copper, 35 parts of sulphate of zinc, and 50 parts of cyanide of potassium together, in 5,000 parts of cold distilled water. After the bath has been stirred, it is allowed to stand for from 24 to 48 hours; it is then subjected, in a cold state (from 25° to 30° Fahrenheit), to the action of a voltaic battery, during the same time, and in like manner to the preceding baths. When this bath becomes impoverished by use, the salt of zinc, or copper, which has been absorbed, must be replaced. The bath last described may also be used for bronzing, by substituting about 10 parts of chloride of tin for the 35 parts of sulphate of zinc, and employing an electrode of bronze.

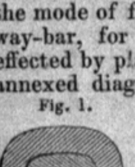
In either of the processes above described, instead of the sulphate of zinc, or chloride of tin, any neutral salts of zinc, or tin acids, may be employed, according to whether the article is to be covered with brass, or bronze, so long as the bath is sufficiently rich in potash, that there may be no action upon blue paper of turnsol. The proportions of the salts of tin, zinc, and copper, may be varied according to the colour desired to be given to the metal coating. This invention may also be applied to the coating of alloys.

RAILWAY BARS AND CHAIRS.

Richard Shaw, of Gold's-green, West Bromwich, Stafford, railway-bar finisher, for "*Improvements in the manufacture of wrought-iron railway bars and railway chairs.*"—Granted October 21, 1847; Enrolled April 21, 1848.

The improvements described in this specification relate to the constructon of railway bars and railway chairs, as also the arangement of the machinery for their construction; and consist, First, in the mode of forming and piling the pieces of iron to form the railway-bar, for preventing the lamination of the metal. This is effected by placing and piling the bars in the manner shown in the annexed diagram, fig. 1, the lower portion of the bar being piled in the usual manner with flat bars, and the upper portion piled with a broad bar bent into the form shown, the edges abutting upon the surface of the bars beneath, and the interior being filled and piled in the usual manner. When the railway-bar is finished, the grain of the metal is arranged in the form represented in fig. 2, and thus no laminating edges occur on the head of the working surface. The other improvements claimed by the patentee are, Secondly, the mode of manufacturing wrought-iron railway bars with protecting rails or flanges affixed thereto, in such a manner that the heads or working surface of the railway-bar stands above the support of the protecting rail or flange. Thirdly, the mode of manufacturing railway-bars with hollow heads or working surfaces in such a manner that the cheeks of the chairs may pass into the hollow of the head or working surfaces for the purposes of support. Fourthly, the mode of rolling railway-bars with rollers placed three high; as also the mode of rolling by the same means the curved bars used in placing and piling for making his improved railway-bars. Fifthly, the construction of chairs for supporting his improved form of railway-bar.

Fig. 1.



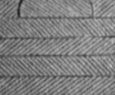


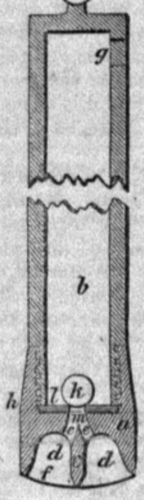
Fig. 2.

BORING AND SINKING.

William Gosswych Gard, of Calstock, Cornwall, engineer, for "*certain Improvements in machinery and implements for boring and sinking.*"—Granted October 21, 1847; Enrolled April 21, 1848.

The object of this invention is to improve the form of the cutting-tool used in boring so as to remove the debris more easily; and also to work the boring instrument more effectively. It is in the form of the tool, however, that the chief novelty of the invention consists. The cutting ends are made of a concave or inverted cap-like form, divided by a cross into four segments, with apertures leading from these segments into a hollow cylinder or shaft, screwed into a neck of the bit, whereby the bored-out materials are removed out of the way of the cutting edges. Fig. 1 represents a vertical section of the borer or bit, constructed according to this invention; and fig. 2, an under plan view of the same, showing the cutting edges. The shaft or hollow part *b*, forms the receptacle for the bored-out materials. This hollow shaft has the part *a*, which forms the cutter, screwed or otherwise affixed thereto, it being made of steel or some other hard metal. The cutting face is of a hollow form, or rather of four distinct hollows, the area being divided by a cross into four sections *d, d, d, d*, (fig. 2), each separate hollow terminating in a hole *e*, leading to a main opening *m*, in the trunk of the borer. The outside diameter of the cutter from the cutting-edge to the point *h*, is of a cylindrical form, and from the point *h*, (fig. 1), to where it joins the hollow shaft, it is tapered about half an inch in order to clear the shaft-part *b*, and allow it to pass freely after the cutter. The cutting edge, forming the circumference, is bevelled only on the inside; consequently, the material, which becomes detached by the blow, is projected inwards and upwards, leaving the external part free from obstruction in its working. The pieces detached by the cutting edges, forming the cross, are also projected upwards, and by the concave form of each section are all conveyed into the openings *e, e, e, e*, to the main channel *m*. A valve-seat of brass *c*, (fig. 2,) is secured in its place by having the stem *b*, screwed down on its surface. This valve-seat has its opening in the centre, corresponding with the main channel *m*, and is fitted with a ball-valve *k*. The detached materials pass up the main channel *m*, into the body of the stem *b*, at each successive stroke of the borer; the quantity of materials detached each time nearly filling the concavities *d, d, d, d*; but by being conveyed directly into the receptacle, they are prevented from impeding the operation of the cutters. The valve *k*, which is prevented from rising too high by a cross-pin in the stem, cuts off any return downwards of the borings. In this manner may the operations of boring be continued until the entire capacity of the stem *b*, is filled, when it is to be withdrawn from the boring, and the contents removed, which may be effected by turning the bit upside down, when they will pass out of the aperture, *g*; but the patentee prefers, when the detached materials are of a dry description, to keep the tool vertically in its boring position, and by raising up the valve from below, to allow the contents to run out.

Fig. 1.



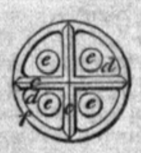


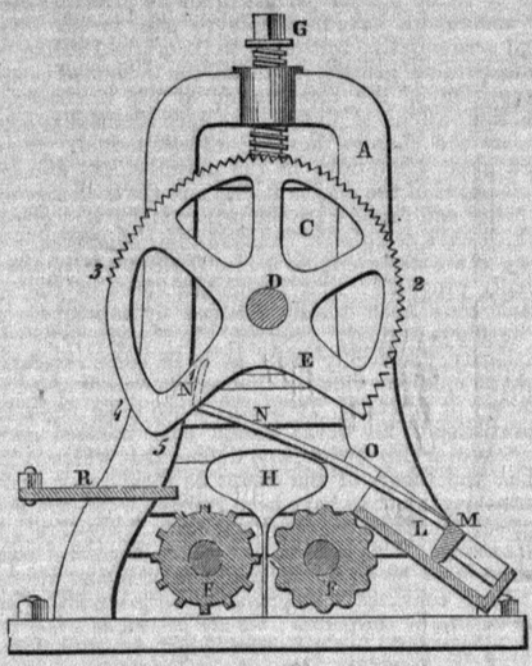
Fig. 2.

The second part of the invention, which relates to the mode of working the boring-tool, needs little description, as it contains nothing that is novel in principle. The patentee adopts the Chinese mode of boring, by fixing the tool to a chain or rope, and producing the effect by continually lifting it up and letting it fall, the height of the fall being regulated by the resistance to be overcome. There is a lever attached to the chain at the top, to one end of which weights are suspended, for the purpose of counter-balancing the increased weight of the chain as the depth of the boring increases, so that the working may be rendered as uniform as possible.

MANUFACTURE OF IRON.

Alfred Vincent Newton, of Chancery-lane, Middlesex, for "*Improved machinery for blooming iron.*" (A communication.)—Granted October14, 1847; Enrolled April 14, 1848.

This invention is for the purpose of more effectually compressing or shingling puddles, balls, or loups of iron into blooms. The improvements are—Firstly, the mode of compressing or shingling by means of a compresser acting in combination with two rollers, and producing therefrom a bloom. Secondly, in the use of cheeks, between which the bloom is formed, having springs at their backs for the purpose of setting and keeping the ends of the blooms square and of proper shape; these cheeks act in combination with the cam-formed compresser and rollers. A third improvement consists of an arrangement of apparatus for feeding the shingling-apparatus with balls to be shingled, and for discharging the bloom when sufficiently compressed and shingled. These combined improvements are represented in the annexed sectional elevation. A, the cast-iron frame of the machine, securely fastened to the bed-plate B; within the upper part of the frame are sliding blocks, C, C, forming bearings for the shaft D, upon which is mounted and properly secured the cam-shaped compresser E, of the peculiar form shown. The periphery of the compresser is eccentric to its centre of motion, for the purpose of squeezing and compressing the ball of iron between the periphery thereof and the rollers F, F; this eccentricity of the periphery of the cam-shaped compresser commences at the point 1, where it begins to impinge upon the ball of iron submitted to its action, and continues round three-fourths of the whole circumference of the compresser to the point 5, in the following manner—namely, from the point 1, of the periphery, to the point 2, thereon, the eccentricity is very abrupt: the periphery recedes from the centre quickly outwards from the centre of motion for the purpose of more quickly and effectually compressing the ball of iron and squeezing out the impurities therefrom; from the point 2, to the point 3, the eccentricity is more gradual; from the point 3, to the point 4, the eccentricity is still less, the point 4, being at the greatest distance from the centre of the motion; from the point 4, to the point 5, the eccentricity of the periphery is reversed, that is, it inclines very slightly inwards towards the centre of motion; the whole space from the point 5, to the point 1, being one-fourth of the whole circumference, is left open and free for the purpose of allowing sufficient time for discharging the bloom produced by the last revolution of the compresser, and for receiving into the machine another ball or loup of iron to be shingled. The periphery of the compresser is also formed with teeth or indentations thereon, for the purpose of more effectually entering into the ball or loup of iron and squeezing out the impurities from it; these teeth or indentations from the point 1, on the periphery of the compresser, to the point 2, are very deep, for the purpose of entering more deeply into the ball at the commencement than at any subsequent period of the process; from the point 2, to the point 4, the teeth gradually become less coarse, being fine at the point at 4; from the point 4, to the point 5, the periphery is nearly or quite plain. Another advantage attending the construction of the periphery of the cam-shaped compresser, is the turning the ball or loup of iron round upon the lower rollers by means of the grip or hold of the teeth or indentations, the lower rollers F, F, are placed in the position shown below the compresser E, at such a distance therefrom as to suit the size of the ball or loup of iron to be shingled and the size of the bloom to be produced; these rollers F, F, revolve in bearings fixed to the main frame A, of the machine; they are placed close together but not in contact; the peripheries of these rollers are provided with projections thereon, for the purpose of effectually turning the ball or loup of iron round while under operation, and thus subjecting every surface of it to the squeezing action of the compresser. The rollers F, F, are connected by toothed gearing with the cam-shaped compresser E, so that they revolve in different directions, also the peripheries of the rollers and the periphery of the compresser must revolve at nearly equal velocities; there is a mode of adjusting the distance of the compresser E, from the rollers F, F, to suit the quantity of metal in the ball or loup by means of the set screw G, passing through the head of the frame A. For the purpose of setting up the ends of the bloom square and compressing it endways, at the same time that it is compressed by the compresser and the rollers, the patentee employs his second improvement—namely, the spring or yielding cheeks; these cheeks H, H, are placed one on either side of the compresser E, over the rollers F, F, the compresser in revolving passing between them; to the back of each of the cheeks are secured two rods or studs passing through holes in the main frame, which thereby serve as guides to them. Around the rods, and bearing stiffly against the backs of the cheek, and the inside of the main frame A, are helical springs, for the purpose of pressing the cheeks H, H, towards each other, and thereby pressing and setting up the ends of the bloom of iron when pressed outwards by the action of the compresser; the outer ends of the rods are provided with washers and pins for the purpose of preventing the springs from pressing the cheeks too near together, and thereby coming in contact with the sides of the compresser E. The front faces of the cheeks (those which act against the ends of the bloom of iron) are of a convex form, somewhat flattened in the middle. The feeding-apparatus, which constitutes the patentee's next improvement, consists of a trough or frame L, attached to the main frame A, in front of the machine in an inclined position: within this trough or frame is placed the plate or frame M, to which are attached the two bars N, N, one on either side; they move in the guides O, O; upon the base or frame M, is placed the ball or loup of metal to be fed into the machine; the frame M is kept back by a balance-weight below the foundation of the machine; the end of the bars N, N, terminate in the hooked shape shown at N′. The mode of feeding is this:—the ball or loup of metal to be operated upon is thrown upon the bar or frame M, where it remains until the compresser comes into the position shown in the engraving, that is, when the compressing surface of the compresser is out of action with the rollers, and the open or free space of the compresser from 5 to 1, is over the rollers, thereby allowing an opportunity for discharging the last-formed bloom, and receiving another ball or loup to be operated upon; at this moment two pins or studs, projecting from the sides of the compresser, come in contact with the ends N′, N′, of the bars N, N, which is thereby drawn upwards, and the ball or loup deposited upon the rollers F, F. At the same time also, an arm or crank, fixed upon the compresser-shaft D, outside the main frame, acts upon the bar Q, which is connected by a lever to the discharging-plate R, in such manner that the bloom of iron is discharged from the machine at the back at the same time a fresh ball or loup is fed into it at the front. The discharging-apparatus is retained in its proper position during the shingling process, by means of a spring.



The patentee claims—First, the arrangement of machinery as described, for compressing or shingling puddles, balls, or loups of iron into blooms. Secondly, the spring or yielding cheeks for setting up the ends of the blooms, as also the cam-shaped compresser and rollers as described. Thirdly, the feeding and discharging apparatus.

A CENTRE-VENT REACTION WATER-WHEEL,

Communicated to the Franklin Institute, U. S., by Z. Parker, *of Philadelphia.*

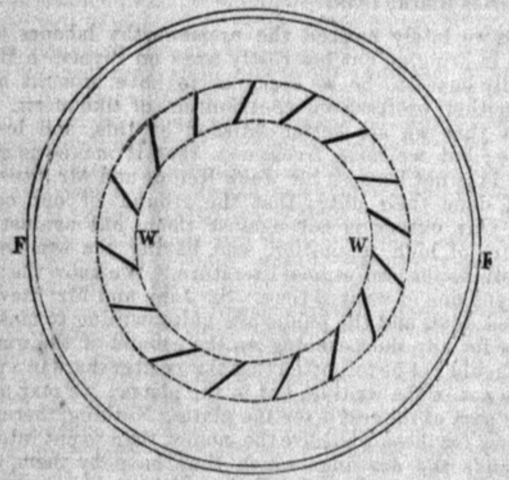
In my notes of the experiments on the centre-vent reaction wheel at Troy, I mentioned the fact of the small amount of water discharged, in proportion to the aperture, and of its disposition to uniformity under all velocities of the wheel. [See *Journal, ante* p. 110.]

I might have stated that in all cases in which the vanes of the wheel direct the water nearly tangentially to the inner circle of the annular rim of such wheels, the quantity discharged (under circumstances of full supply) appears to be about 50 per cent. of the theoretic discharge; and that this proportion appears to be but little affected by changes in the velocity of the wheel, from being held stationary, to any velocity it may acquire by the pressure of the water on the vanes;—or by any change in the circular motion of the water entering the wheel (at its verge), either with or contrary to the circular motion of the wheel.

In corroboration of this position, we have the experiments at Troy, in which the discharge (at the maximum) was a trifle less than 50 per cent., owing probably to the unfavourable form of the vanes;—and the fourth set of my model improvements (the notes of which you have), where the water passed, inwardly, through a structure, which, when the wheel was removed, was exactly similar to such a wheel,—the quantity discharged in this instance, being just 50 per cent. of the theoretic discharge.

Among the many "interesting objects" at the American Institute Fair, of the present season, there was a centre-discharge reaction wheel, in a very neatly constructed model, the wheel, about four inches in diameter, being made of brass and neatly finished. To the under side of a disk, attached to a vertical shaft, were attached plane vanes extending from the verge to a circle about one-half of an inch from the verge. To these vanes was attached the annular rim, in the usual way. The angle of the vanes directed the water somewhat without the direction tangent to the inner diameter of the annular rim, and after passing into the wheel, it fell through the opening of the rim, and bottom of flume some inches, into a basin beneath. The flume was a glass cylinder about seven inches diameter; and the supply, a constant stream of "Croton" through a lead pipe,—falling in from the top of the cylinder.

Suspecting from my former experiments that the discharge of such a wheel must be uniform under all velocities, I took the opportunity of experimenting on this, by applying friction to the shaft (about half an inch in diameter) with my fingers. *I could make no sensible variation in the height of surface by any change of velocity, from being held, to running it beyond its natural free velocity (by rolling the shaft between the thumb and fingers), nor by turning the wheel backward.*



The accompanying cut represents a section of the vanes.

TREATISES ON THE STEAM-ENGINE.

The want of a satisfactory treatise on the steam-engine has long been felt. The existing treatises, notwithstanding their general merits, do not supply the whole of the information which the engineer requires; and the looseness of scientific views, and the neglect of systematic arrangement, observable in most of them render much of the knowledge imparted either dubious or inaccessible.

We have been frequently called upon to give advice in the choice of a work on this important subject. In answer to correspondents who had made an application of this kind, we replied some time ago (vol. IX., page 392), that a complete treatise appeared to us to be one of the desiderata of engineering literature. Several subsequent letters strongly confirmed the opinion then expressed, that the existing treatises on the theory, construction, and routine management of the masterpiece of mechanical invention are not what they ought to be—*accurate*, *complete*, and SYSTEMATIC.

It is no disparagement of the efforts of those who have already written on the subject, to assert that we now know more of it than they did. This branch of knowledge is necessarily progressive. The operations of the steam-engine have been extended in diversity and magnitude, and have attained a universality which to its great inventor himself would have appeared incredible. The new demands of the manufacturer, engineer, navigator, and mechanician, stimulate and suggest new applications of the most powerful and most obedient of the agents of human industry: upon machinery so complicated, the fertility of modern invention and the boldness of modern enterprise are incessantly and successfully exerted: while the minute details of the apparatus are constantly receiving fresh improvements, as practical skill becomes more and more developed and refined.

Yet the apparatus itself is in the main unchanged. The steam-engine of WATT is the steam-engine of 1848: the great inventor bequeathed it to us almost perfect in all its principal parts, and the small amount we have been able to add to his legacy is a striking and accumulative testimony to its original value.

This consideration greatly simplifies the labour of compiling a perfect exposition of the combination of the mechanism. But though the innovations of practice be here confined to details, in other respects the changes have been fundamental. Experience has effected great alterations in the purposes, the management, and the dimensions of the engine itself; and the accessory parts, of which the boiler and furnace are the principal, have received modifications which have completely changed their character.

The *theory* of the steam-engine is also fundamentally different to that originally proposed: that Tredgold's views of the *rationale* of its action have been totally falsified by subsequent experience may be unhesitatingly asserted. It is much to be regretted that his authority, deservedly great as it in some respects is, has given weight to opinions which of themselves cannot stand the test either of theory or practice. It is still more to be regretted that mistaken partiality to his works should have induced subsequent writers to gloss over his errors, and defend that which is indefensible. When the theory of the Count de Pambour appeared, its obvious truths ought not to have been resisted by absurd prejudice in favour of our countryman. De Pambour is *right*—Tredgold and his followers *wrong*. This sounds like a very dogmatic assertion: and we intend it to be so, for if the lucid demonstrations of De Pambour fail to convince his opponents, they are either too perverse or too dull to be converted: we are driven as a last resource to assertion, *ex cathedrâ*, and to resist frivolous contradictions by the weight of great names. The theory of De Pambour had no sooner appeared, than all scientific writers renounced their previous views, and without reluctance signified their adhesion to his.

Not indeed that all his *conclusions* are absolutely indisputable. The chief problem to which he addressed himself was this:—Given the dimensions of an engine, to ascertain the resistance it will overcome at a given velocity, or the velocity at which it will overcome a given resistance. Now, the main difficulty of the question, and that which De Pambour has only partially met, is to ascertain the amount of resistance. It is an essential element, and any uncertainty respecting it affects the whole subject. Without particularising further, we may observe that he has erroneously estimated the resistance to which locomotive engines are subject, and has assumed a law of friction (Coulomb's) which is in this case inapplicable. Another difficulty is in ascertaining the actual efficiency of the boiler. Its apparent evaporation and its effective evaporation are not the same—part of the water being drawn into the cylinders in a liquid state. The amount of "priming" depends on minute and varied circumstances,—the violence of ebullition,—the foulness or purity of the water,—its level in the boiler,—and the capacity of the steam-pipes. Certainly, no mathematical formula, such as De Pambour has laid down independently of these considerations, can be universally and exactly correct.

The materials for an improved treatise are abundant; and those who enter on the task of compiling such a work, should ransack every source of information. Notwithstanding our strictures on Tredgold, we are disposed to think that his work ought to be the basis of a new treatise. There are many reasons which conduce to this conclusion. In the first place, on comparison, his plan and arrangement seem the most perspicuous hitherto published. In the second place, most engineers are familiar with it. This is a great point: readers do not like to be constantly learning out of new books, and engineers especially have seldom time to spare in familiarising themselves with new systems.

The plan which Mr. EATON HODGKINSON has pursued in his edition of the "Treatise on Cast-Iron," appears to be the best for the case before us: he has left his author's text as he found it, appending his own corrections and additions. With respect to a treatise on the steam-engine, the authorities to be searched and cited are numerous and valuable. In pure theory, the views of DE PAMBOUR should be clearly stated, with the modification above suggested. Some of Professor MOSELEY's most useful practical results should be also referred to: his researches respecting the effects of friction of the parts of the engine are too complicated, and depend on data too uncertain, to be available; but some of his investigations respecting the fly-wheel, &c., are invaluable, and have the advantage of leading to simple arithmetical rules.

The great *continental authors* require to be diligently and thoroughly examined. It is principally from the French writers, with Navier at their head, that foreign assistance must be expected; and the system pursued in France in the education of engineers, renders almost every treatise written in that country on practical science worthy of consideration at least. The articles contributed to our own *cyclopædias*, and the recent treatise of Mr. Hann, also furnish several useful suggestions for rules, which an intelligent artisan may understand and apply without a knowledge of mathematics.

The *transactions of learned societies* contain invaluable records of the results of experiment and routine experience. Numerous papers have appeared under the auspices of the British Association and Institution of Civil Engineers, on what we just now designated the most difficult part of the problem of the steam-engine—the resistance to which it is subject; and in reference to the locomotive engine the labours of Mr. Wyndham Harding may be particularised. The transactions of the Royal Society also contain some papers referring to the resistances to marine engines—a subject to which Mr. Scott Russell has long devoted attention.

The *scientific periodicals*—the *Mechanics' Magazine*, the *Journal of the Franklin Institute*, &c., ought also to be examined: they are storehouses of facts of the greatest importance. Of course, discretion and accurate scientific views are indispensable in selecting from the vast mass of contradictory and controversial statements, contained in the correspondence of our contemporaries, but even *extragavant* ideas coming from practical men have some use, if suggested by experience—they serve at least to put debated questions in a new light.

The *blue books* of *Parliamentary* and *Royal Commissions* contain also much that is valuable, amidst heaps of rubbish. It requires keen instinct and patient industry to separate the grain from the chaff; but such a labour must be accomplished, if a perfect work on the steam-engine is to be written. Commissions such as those upon the Gauge question and Atmospheric Railways, are convocations of all the most eminent engineers in the kingdom, and their collected evidence is a synopsis which could not be obtained in any other manner.

There are many other sources of information and separate treatises possessed of great merit, but too numerous to be here recited. These ought all to be referred to. The labour of reference is great, but is not the subject worthy of it?—*the* great marvel of the earth—the wonderful, wonder-working agent upon which the social constitution of the whole world depends—which, when the human family has become so numerous that all its labour can scarcely obtain from nature sufficiency of sustenance, co-operates in this struggle for existence. In some sense, our very lives depend on the steam-engine. Without its aid to convey the emigrant from over-crowded shores—to interchange the products of various soils and climates—to convert those products into clothing and other necessaries of society,—without, in a word, its help in carrying on the business of the world, the business of the world would become too great to be accomplished.

He who has increased by the least particle the knowledge of the steam-engine, has therefore conferred on society a benefit of which it is impossible to foresee the extent. Without hyperbole, a perfect account of the steam-engine would stand among the highest of national undertakings. It can scarcely be expected, however, that any treatise now written can be absolutely perfect, for there are many parts of the subject which it requires the experience of future years to entirely develope. Still, the present epoch is particularly favourable for systematising the knowledge already acquired. A uniformity of practice and experience has been at length arrived at, which may indeed be hereafter extended; but which, in all probability, will never suffer any great fundamental change. The chief difficulty to be encountered, is to render the knowledge *systematic*. If it be not digested—if it be not perfectly consistent with itself—if the whole observe not simple and demonstrable dependence on definite principles, the failure of the undertaking is inevitable. Simplicity and system are the two keys to the success of all works on practical science. We insist the more earnestly on the necessity of scientific connection and unity of plan, because experience has shown how far the neglect of those requisites impairs the utility of a treatise on the steam-engine. That bearing the appellation of the "*Artizan*," will always be in high repute, for the vast quantity of practical information which it contains; but this advantage is greatly diminished by the want of plan. Works which contain the labours of several independent writers should always be subject to the supervision of some controlling editor, who should be responsible for the scientific accuracy of the whole. Many readers of engineering works are necessarily obliged to receive scientific principles on trust—their own previous education being devoted to practical, and not to theoretical pursuits. It is all-important that such readers should not be misled. The slightest error of principle, the neglect of particulars in themselves apparently trivial, will frequently lead to the greatest errors. Of what importance is it then that all mechanical doctrines should be accurately conceived and strictly expressed?

Lastly, it should be carefully and constantly explained to the student, that the abstract laws of mechanics are *demonstrated*—that respecting them, debate would be as frivolous as respecting the truth of the conclusions of Euclid. *The only persons who argue about mechanics are those who are imperfectly acquainted with the science.* In the applications of mechanics to the steam-engine, the only questionable topic is the accuracy of data—the methods of calculating from those data have been long since settled beyond all possibility of dispute.*

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* We observe with satisfaction, that a new and improved edition of Tredgold on the steam-engine is proposed. The name of the publisher is a guarantee for the excellence of the typography and value of the illustrations. If scientific accuracy, which we have here insisted upon as all-important, be also attained, a most valuable addition to the engineer's library will be produced.

REVIEWS.

Account of the Skerryvore Lighthouse, with notes on the Illumination of Lighthouses. By Alan Stevenson, LL.B., F.R.S.E., M.I.C.E., Engineer to the Northern Lighthouse Board. Edinburgh: Adam and Charles Black, 1848.

When we lately noticed the praiseworthy labours of Sir John Rennie, in bringing out his costly work on Plymouth Breakwater, we hardly hoped to be so lucky as to have brought before us so soon another professional contribution of like merit. It may be thought that we are better satisfied by this, and less ready to grumble; but we must freely own that it makes us grumble the more. It is not because Sir John Rennie and Mr. Stevenson have so well done their duty, that the ground of our complaint is gone. Our outcry is not against them, but against the other engineers of high reputation, who, having the same means, have done nothing for professional literature. We know the answer: the hackneyed one of want of time. Sir John and Mr. Stevenson have answered that, and the public are quite willing to make every allowance for any short-coming on the ground of the want of time; but it should not be forgotten that the greater share in a professional book is not in the writing, but in the plates: we may add that the greater part of the cost is for the plates. Nothing, therefore, can be more easy for those who have the money, than to put into the engraver's hands the drawings which they have by them, and then, if they cannot themselves do all the writing which is required, they must get some one to help them; and that, too, is only a matter of money. In any way in which the question can be looked at, it resolves itself into one of outlay, and of good will; and we cannot help saying, that it is far from creditable to our engineers to be so neglectful of publishing proper records of their works. We cannot free them from the charge of want of will, for it is too well known to spirited engineering publishers, to authors, and to editors of professional works, that it is next to impossible to get information, either from the leading engineers or their assistants. Thus, what is published is mostly very imperfect; and then the parties who ought to have given the information are the first to decry what has been done, and to lay blame for what is wrong, or is wanting.

We would rather believe that the wrong lies in this want of will, than in want of liberality, because many of those open to blame have always given very freely to professional institutions. Want of means we cannot allow; for those who can spend money in buying boroughs, and in getting a seat in parliament, can well give a few hundred pounds for bringing out a book. If, too, the evil lay in the want of liberality, we should be hopeless of overcoming it; but if it be from want of rightly thinking about it, or from want of the will to set to work, then we have some trust from what we know of our leading men, that they will not in the end be found wanting; but will, after careful thought, do that which they find to be right. The matter is, indeed, one of great weight, and mostly as it touches the good name of those concerned; for how can the standing of the profession be kept up, if its members lie open to the charge of mere money-grubbing, and an utter carelessness of doing anything to keep up professional knowledge? The engineer has been taught by others, and as he cannot repay those who have taught him, he must for his share teach others. By building the Eddystone Lighthouse, Smeaton laid the groundwork of the greater lighthouse on the Bell-rock; and Mr. Alan Stevenson, following in the footsteps of his father, has outdone him in his great work at Skerryvore. Had we not the first work, the last would still be wanting; but it is by storing up knowledge, by gathering little and little, that it grows until we can work out those wonders which are the pride of all time. The slight tramway has, by the work of many hands, been brought to such a height that it has become the strong arm of civilization. Time has been overcome, and the furthest ends of the land brought, as it were, within grasp. Why, however, do we talk of such things? Why do our great men take their seats at the meetings of the Institutions—why have they anything to do with them, if they do not acknowledge them to the full?

The Institution of Civil Engineers sets out with the purpose of communicating knowledge to its members, and of keeping a record of every new work. Each member is pledged to write something, and to give his mite to the common stock. This is an acknowledgment of the principle, and it would be well if the members of the Institution were, in their choice of officers, to bear this in mind, and only name those of their brethren as president and vice-presidents, who had given their fair share to professional learning. This would be a right acknowledgment to those who, like Sir John Rennie, George Rennie, Sir John Macneill, and Alan Stevenson, have done something, and would give a spur to others.

So long as engineers look after money only, and do not care for their good name, so long will they be without their right weight with the public; and so long will the government be able to trample on them, and give their emoluments to the military engineers. It is not enough that they have raised great works—the evil-willed will always say, those were done for money, and will be ever ready to take away from the honour which would otherwise be awarded. The thankfulness of the public is not so sure, that any means of earning it can safely be left undone. How many great men are there whose names are almost forgotten, and whose deeds are unknown! Very few, when they see a canal, think of the labours of Brindley, or when they see a locomotive, think of how much we owe to Trevithick. Those who were careless of their good names in their lifetime, would have little right to complain of the forgetfulness of those who came after them; and our great men of this day can look forward to nothing better. If they have tasted the ill-will of those amongst whom they live, and who see them and their works, they cannot reckon that they will fare better hereafter, when they have done nothing to show that they care for others as well as for themselves.

Smeaton lives in his writings, as much as in his other works; and he has earned for himself a share in the works of those who have followed in his path. Thus, Mr. Stevenson bears witness to Smeaton's good works. Before beginning the Skerryvore lighthouse, he carefully read what had been written by the great man who went before him. Even to the shape or bearing of a stone, or the fitting of a joint, Smeaton had carefully put down what he had done, and Mr. Stevenson was able to come to a sound judgment as to what he himself thought of doing. The knowledge of a hundred years was at once brought to bear, and the engineer has outdone the works of his great master.

Skerryvore will withstand for hundreds of years the storms and blasts which burst upon it, and those who look at it will see, with wonder, its strength and its bulk, and acknowledge its builder has done his work. A rock of stone is raised upon the crags of Skerryvore, but the even seams hide all the work within: each layer buries from sight the cunning handiwork beneath it. The very finish stands as it were in witness against the hardihood of the builder; and there is nothing scarcely to show his skill,—nothing to show the care, the sweat, the peril spent in putting stone on stone, among threatening waves and sweeping winds, which shook the narrow dwelling of the workmen, ready to dash them into the troubled sea which yawned beneath them. There is greater heroism in fighting against such risks, than in shedding blood in every field of Scinde, or in warring against the bold highlanders of Cabul. Nor can the sailor even claim the perils of the ocean for himself; but the engineer shares them with him. Great as are the risks which our seamen have to meet, they are not greater than Mr. Stevenson and his workmen underwent on the rock of Skerryvore. The first shelter they raised was wrecked in a winter's storm, and they dwelt for months in a barrack upon the rock, which they could not but believe was threatened with the same end. Cranes, windlasses, forges, and anvils, were tossed about the rock by the storm, as freely as pebbles, dashing timbers to pieces, and helping to tear away the works which were laid down. No tool could be left for a day without being lashed to ring-bolts, and even these were sometimes snapped off. The surf dashed in sheets against Mr. Stevenson's window, fifty feet above the sea; and one night, he tells us the barrack reeled so with the shock of the waters, that all the men leaped from their hammocks with a fearful wail, believing that their doom was come, and that they should be swept into the seething waters. Here were they sometimes laid up for days, unable to stand upon the slippery rock, or to face the sweeping storm; and lying in their hammocks day and night, for shelter against the bitter cold. Sometimes they were left almost without food, for the steamer could not always keep the sea; and once their stock was brought down to the wants of one day only. At all times it was hard to land, or to get the stones out of the lighters; and often they were hauled back by the steamer after snapping every warp. The rock was as smooth as glass, and so narrow that the workmen had hardly room to work. In blasting for the foundations, there was no shelter under which the men could lie down; so that Mr. Stevenson had to cover the rock with matting when blasting was going on. On this spot, they worked under the broiling sun while daylight lasted, snatching only hasty meals; and their nights they spent, the first year, in an uneasy ship, which often made them sea-sick; and afterwards in the barrack, whence the storm might have in one moment hurled them from sleep to death.

The few words which Mr. Stevenson gives to these risks he and his fellow-workmen underwent, have all the charm of romance, and may well be put side by side with any tale of the sea. They are most pleasing, however, as a record of true courage, successfully exerted in a useful undertaking. Had we not this record, we should know but little of what Mr. Stevenson has done, or how to rate him at his true worth; indeed, half of his merit would be lost, for the mere workmanship is the least which he can boast of; and others could match him even in that. The skill, the foresight, the battle with the hardships of every kind, which beset this undertaking, tasked his powers to the utmost; but he answered to the call.

Professional gallantry in meeting danger is, we are happy to say, far from rare. The engineer is ever ready to share with the workmen in every work of risk, and there are few great works which have not some tale of gallantry to tell. The lighthouses of the Eddystone, the Bell-rock, and Skerryvore, were beset with peril; in the tunnels under the Thames, Trevithick, Sir Mark Brunel, and Mr. Gravatt, risked themselves; and daily, wherever a new locomotive is tried, a new boiler is set up, a new mine opened, or a new engine built, some engineer puts his life at stake. Courage is not the virtue of a blue coat, or of a red one: the medical man who meets typhus in the abodes of the poor, is a greater hero than he who boards another's bulwarks, or who storms a breach; because he has no hope of glory or advancement, and a greater chance of danger.

The reader of Mr. Stevenson's book is sure to be struck by the thought of its value to engineers now and hereafter, but most to those in our far settlements, who have no chance of going to Skerryvore, or to the Eddystone; and who, indeed, if they had, would see the work—but not how it has been done. Mr. Stevenson has been careful fully to explain every step which he took, to account for his failures, to give the reasons by which he was led, and to describe every process, however common, or however trifling. He thought that nothing belonging to his work was beneath him; and as he looked into everything, he was enabled even to make improvements in many of the common operations. By recording what he did, he enables others to do likewise, and to follow in his path; and no one thinks that his book is too long,—but rather, each wishes that it were longer, though nothing is left out. Care in such works is highly needful, and is most wanted where there are no bounds to the outlay which may be made. By leaving out such dovetails and ribbands as Smeaton and Thomas Stevenson had in their lower layers, Mr. Stevenson saved above four thousand pounds in the cost of dressing the granite, and without any loss of strength or safety. By getting everything ready before-hand, he had no loss of time in running up his building on the rock, but had every stone dressed, so that it was right to the eighth of an inch; and the whole building is as well finished as if it were raised upon the main land, with every help at hand,—whereas, there was hardly room on the rock for blasting, no mooring ground, no pier, no quay, hardly room for a windlass, and everything was brought from Hynish, twelve miles off.

Whoever reads this book must think more highly of the labours of engineers; but when we look at the wonderful works which are spread over this land, we cannot but wish that we had as good records of them. The public will name many who are well able to do justice to their own labours, and the fulfilment of the public wish would greatly enrich our libraries. The history of the Liverpool and Manchester Railway, by Mr. George Stephenson, would be a hand-book for all time. Mr. Robert Stephenson, M.P., has in the London and Birmingham Railway a good subject for illustration. Mr. Locke, M.P., can do no better service to the profession than by the publication of an account of the Grand Junction Railway. Mr. Brunel has spent many years upon the perfection of the broad-gauge system, and has in the Great Western Railway achieved a success which should not be forgotten. Mr. Cubitt has allowed his assistants to give accounts of the tunnels and blasting operations on the South Eastern Railway, but a full account of the whole line is wanted from his own hands. We hope the time is not far off when we shall see these among other contributions to our professional literature.

We shall now call attention to the rocks on which the Skerryvore lighthouse was raised. They form part of a long reef, 11 miles to the south of Tyree, in the outer range of the Hebrides or Western Isles, so that they are in the sea-way between Scotland and Ireland; and ships from seaward, if they miss the north of Ireland, are often driven on Skerryvore, where many wrecks have happened. In 1814, an act of parliament was obtained for building a lighthouse, but it was not till 1834 that Mr. Alan Stevenson was sent to make the first survey.

At low tides, Skerryvore measures about 280 feet square; but it is cut up by gullies of unlooked-for depth, so that the solid part is only 160 feet by 70 feet. On this a loaf of rock, about five feet broad, rose to the height of eighteen feet above high-water level, the greater part of the rest being about six feet above that level. The rock Mr. Stevenson calls a syenitic gneiss, consisting of quartz, felspar, hornblende, and mica.

It was not till the summer of 1835 that the survey was finished, and Hynish, in the wretched island of Tyree, was chosen for the workyard. This is 12 miles from Skerryvore. In 1836 and 1837, quarries were opened in Tyree, and in the latter year the pier at Hynish was begun. Mr. Stevenson was now busy in drawing up his plans, and here he came to a weighty question.

"A primary inquiry, in regard to towers in an exposed situation, is the question, whether their stability should depend upon their *strength* or their *weight;* or, in other words, on their *cohesion*, or their *inertiæ?* In preferring *weight* to *strength*, we more closely follow the course pointed out by the analogy of nature; and this must not be regarded as a mere notional advantage, for the more close the analogy between nature and our works, the less difficulty we shall experience in passing from nature to art, and the more directly will our observations on natural phenomena bear upon the artificial project. If, for example, we make a series of observations on the force of the sea, as exerted on masses of rock, and endeavour to draw from these observations some conclusions as to the amount and direction of that force, as exhibited by the masses of rock which resist it successfully and the forms which these masses assume, we shall pass naturally to the determination of the *mass* and *form* of a building which may be capable of opposing similar forces, as we conclude, with some reason, that the mass and form of the natural rock are exponents of the amount and direction of the forces they have so long continued to resist. It will readily be perceived, that we are in a very different and less advantageous position when we attempt, from such observations of natural phenomena, in which *weight* is solely concerned, to deduce the *strength* of an artificial fabric capable of resisting the same forces; for we must at once pass from one category to another, and endeavour to determine the *strength* of a comparatively *light* object which shall be able to sustain the same shock, which we know, by direct experience, may be resisted by a given *weight*. Another very obvious reason why we should prefer *mass* and *weight* to *strength*, as a source of stability, is, that the effect of mere *inertiæ* is constant and unchangeable in its nature; while the *strength* which results, even from the most judiciously disposed and well executed fixtures of a comparatively light fabric, is constantly subject to be impaired by the loosening of such fixtures, occasioned by the almost incessant tremor to which structures of this kind must be subject, from the beating of the waves. It was chiefly on these grounds that the Commissioners of Northern Lights, after consulting a Committee of the Royal Society of Edinburgh, and Messrs. Cubitt and Rennie, civil engineers, rejected the design of Captain Sir Samuel Brown, R.N., who volunteered a proposal to build an iron pillar at the time that the erection of the Skerryvore Lighthouse was determined on in 1835. Mass, therefore, seems to be a source of stability, the effect of which is at once apprehended by the mind, as more in harmony with the conservative principles of nature, and unquestionably less liable to be deteriorated than the *strength*, which depends upon the careful proportion and adjustment of parts."

In fixing the quantity of matter needful to produce stability, and in determining the shape of the tower, Mr. Stevenson had to proceed empirically, for there is a want of sufficient experiments. Mr. Stevenson gives, however, a full discussion of the data, which are available. At this point he brings in an interesting comparison of the three great lighthouses.

	Height above first entire course.	Contents of tower.	Diameter.	
			At Base.	At Top.
	Feet.	Cubic feet.	Feet.	Feet.
Eddystone ..	68	13,343	28	15
Bell-rock ..	100	28,530	42	16
Skerryvore ..	138·5	58,580	42	15

The first barrack raised was swept away by the sea, so that in 1839 the summer was spent in raising another, and in excavating the foundation of the lighthouse tower. The difficulty of doing this may be appreciated from the following account:—

"It was commenced on the 6th of May, and was continued up to the last hour of our remaining on the rock, on the 3rd of September. A more unpromising prospect of success in any work than that which presented itself at the commencement of our labours, I can scarcely conceive. The great irregularity of the surface, and the extraordinary hardness and unworkable nature of the material, together with the want of room on the rock, greatly added to the other difficulties and delays, which could not fail, even under the most favourable circumstances, to attend the excavation of a foundation-pit on a rock at the distance of 12 miles from the land. The rock, as already noticed, is a hard and tough gneiss, and required the expenditure of about *four times* as much labour and steel for boring as are generally consumed in boring the Aberdeenshire granite.

After a careful survey of the rock, and having fully weighed all the risks of injuring the foundation, I determined at once to enter upon a horizontal cut, so as to lay bare a level floor of extent sufficient to contain the foundation pit for the tower. The very rugged and uneven form of the Rock made this an almost necessary precaution, in order to prevent any misconception as to its real state, for it was traversed by numerous veins and bands inclined at various angles, on the position and extent of which the stability of the foundation in no small degree depended. That operation occupied 30 men for 102 days, and required the firing of no fewer than 246 shots, chiefly horizontal, while the quantity of material removed did not greatly exceed 2,000 tons. It was a work of some hazard; for the small surface of the Rock confined us within 30, and sometimes within a dozen yards of the mines, while its form afforded us no cover from the flying splinters. The only precautions we could adopt were to cover the mines with mats and with coarse nets, which I had caused to be made during the previous winter, of the old ropes of one of the lighthouse tenders, and in each blast to apportion very carefully the charge of powder to the work that was to be done. That was managed with great skill by Charles Barclay, the foreman of the quarriers, who charged all the bores, and, along with myself, fired all the shots. So completely did the simple expedient of covering the bores with nets and mats check the flight of the stones, that, except on one or two occasions, none of the splinters reached us, and all the damage done was a slight injury to one of the cranes. Perhaps, also, our safety may, in some measure, be attributed to a change which I introduced into the mode of charging the horizontal shots, by which all the risk of pushing home the powder in the ordinary mode with the *tamping rod* is avoided. That change consisted in using a kind of shovel, formed of a rod, armed with a hollow half-cylinder of sheet copper, which contained the powder, and being inverted by giving the rod half a turn round its axis, made the powder drop out when the cylinder reached the bottom of the bore. It was in all respects, excepting size, the same as the charging-rod used for great guns. The amount of materials removed by blasting, as nearly as I could ascertain, was only about 1,000 cubic yards; and, taking all the circumstances into account, it may be doubted whether there be any instance in modern engineering of an operation *of so small an extent* occupying so much time, and involving so great risk. The blasting of the rock, however, was not the only difficulty with which we had to contend, for it also became necessary to remove the quarried materials, amounting to about 2,000 tons, into the deep water round us, to prevent their being thrown by the waves upon the rock, and so endangering the future temporary barrack. That was rather a laborious work, and occupied two cranes, with temporary runs and trucks, during the greater part of the time we spent on the rock. I am well aware that the quantity of materials which I have just mentioned, will be apt to produce a smile from those who have been chiefly conversant with the gigantic but simple operations which generally characterise the great railways of this country; but if it be remembered that we were at the mercy of the winds and waves of the wide Atlantic, and were every day in the expectation of a sudden call to leave the rock, and betake ourselves to the vessel, and on several occasions had our cranes and other tools swept into the sea, the slowness of our progress will excite less surprise; and still less will those who duly weigh the dangers of our daily life, both in our little vessel and on the rock, and who, at the same time, reflect on the many striking proofs which we almost every hour experienced of the care of an Almighty hand, be disposed to withhold their sympathy from the heartfelt expressions of gratitude which often went round our little circle in the boats, as we rowed in the twilight from the rock to the ship. Isolation from the world, in a situation of common danger, produces amongst most men a freer interchange of the feelings of dependence on the Almighty, than is common in the more chilly intercourse of ordinary life.

With a view to lessen the dangers of blasting in such a situation, I had provided a galvanic battery on the plan proposed by Mr. Martyn Roberts, but I used it less frequently than I intended. The attachment of the wires were very liable to be broken from various causes, where there were many men congregated in a small space; and as we could not venture to leave the apparatus on the rock, the frequent re-shipment of it in a heavy sea was another cause of the derangement of its parts. I soon, therefore, laid it aside, and only had recourse to it when any work was to be done under water, or in cases where the simultaneous firing of several mines (for which it is admirably adapted) was of importance in effecting any special purpose.

When the floor had been roughly levelled I again carefully surveyed the rock, with the view of fixing precisely the site of the foundation-pit, and of taking advantage of its form and structure to adopt the largest diameter for the tower of which the rock would admit. In some places I found that parts of the rock, apparently solid, had been undermined by the constant action of the waves, to the distance of 13 feet inward from its face; but none of those cavernous excavations reached the main nucleus, so that, after much deliberation and repeated examinations of all the veins and fissures, I was enabled to mark out a foundation-pit 42 feet in diameter, on one level throughout. That was a point of no small importance; and although it had cost great labour at the very outset, much time was saved by it in the subsequent stages of the work. Not only was the labour thereby avoided of cutting the rock into separate terraces, and fitting the blocks to each successive step, as was done by Smeaton at the Eddystone; but the certainty that we had a level foundation to start from, enabled us at once to commence the dressing of stones without regard to any irregularities in the surface of the rock; and the building operations, when once commenced, continued unimpeded by the necessity for accommodating the courses to their places in the foundation-pit, so that the tower soon rose above the level, at which there was the greatest risk of the stones being removed by the waves before the pressure of the superincumbent building had become great enough to retain them in their places.

The outline of the circular foundation-pit, 42 feet in diameter, having been traced with a trainer on the rock, numerous jumper-holes were bored in various places, having their bottoms all terminating in one level plane, so as to serve as guides for the depth to which the basin was to be excavated. The depth did not exceed 15 inches below the average level, already laid bare by the cutting of the rough horizontal floor which has just been described; and before the close of the season of 1839, about *one-third* of the area of the circle had been cleared, and was ready for the final pick-dressing which prepared it for the reception of the first course. The excavation of this circular basin was conducted with the greatest caution, and few shots were permitted to be fired lest the foundation should in any place be shaken by the action of the gunpowder on any of the natural fissures of the rock. The work was chiefly done by means of what are called *plugs and feathers*. In that part of the work the bores were nearly horizontal, and the action of the *plug and feathers* was to throw up a thin superficial shelf or paring of rock of from 6 to 12 inches in depth, and not more than 2 feet square. By that painful process an area of about 1,400 superficial feet was cleared. The chief trouble connected with that operation was cutting, by means of the pick, a vertical face for the entrance of the horizontal *jumpers* or boring rods; and wherever advantage could be taken of natural fissures it was gladly done. Another considerable source of labour was the dressing of the vertical edges of the basin, as that implied cutting a *square check*, 15 inches deep and about 130 feet long, in the hardest gneiss rock; and the labour attending which, can only be fully estimated by a practical stone-cutter who has wrought in such a material. The plan employed was to bore all around the periphery of the circle, 1⅜ inch vertical jumper-holes, 6 inches apart, to the required depth, and to cut out the stone between them. The surface thus left was afterwards carefully dressed, so as to admit vertical and horizontal moulds, representing truly the form of the masonry which the check was intended to receive. The experience of the labour attending that operation gave me great reason for congratulation on having adopted a foundation on one level throughout, instead of cutting the rock into several terraces, at each of which the same labour of cutting angular checks must necessarily have been encountered. The cutting of the foundation occupied 20 men for 217 days in all, whereof 168 days were in the season of 1839, and the rest in the summer of 1840."

It was not till 1840 that this pit was finished, when Mr. Stevenson says—

"The rock, indeed, was in many places so hard as often to make it seem hopeless that tools could make any impression on it. The time employed in the excavation and the number of tools expended on it, were very great, as a pick seldom stood more than three strokes in the harder quartzose veins; but our perseverance was at length amply rewarded by obtaining a foundation so level and so fairly wrought throughout the whole area of a circle 42 feet in diameter, as to present to the view the appearance of a gigantic basin of variegated marble; and so much pleased were the workmen themselves with the result of their protracted toil, that many of them expressed serious regret that the foundation must soon be covered up, so as (we trusted) never to be seen again. In the dressing of the rock much inconvenience arose from the small splinters which flew out before the tools, sometimes rising to the height of 40 feet, and coming in at the windows of the barrack; and after several injuries had been sustained, I at length found it necessary to send to Glasgow for fencing masks to protect the men's faces. In all our work, nothing was more grudged than the occasional loss of half a day in *baling* out the water from the foundation-pit after it had been filled by a heavy sea."

The mortar employed in the building was composed of equal parts of Aberdda lime and Pozzolano earth, being identical with that used by Smeaton.

In 1840, six courses were set, being a mass of masonry equal to the whole of the Eddystone tower. In 1841, 30,300 cubic feet were built, being twice as much as the Eddystone, and more than the whole Bell-rock lighthouse. In 1842, the masonry work was finished.

The general arrangement of the tower is much like that of the Bell-rock lighthouse.

"The ascent to the outside door is by a ladder or trap of gun metal, 26 feet high. The first apartment on the level of the entrance door, is chiefly appropriated to the reception of iron water-tanks, capable of holding a supply of 1251 gallons. The next story is set aside for coals, which are stowed in large iron boxes. The third apartment is a workshop; the fourth is the provision store; and the fifth is the kitchen. Above are two stories, each divided into two sleeping apartments, for the four light-keepers. Over them is the room for the visiting officers; then follows the oil store, and lastly comes the lightroom, making in all twelve apartments. The nearness of the oil store to the lightroom is a great convenience to the keepers, who are thus saved the trouble of carrying the daily supply of oil to the lightroom, up a long flight of steps. The passage from story to story is by oaken trap ladders, passing through hatches in each floor and partitioned off from each apartment in order to prevent accidents and to check cold draughts."

The light was exhibited at Skerryvore on the 1st of February, 1844.

The whole cost of erection was 90,268*l*. 12*s*. 1*d*., but of this very little was spent directly on the lighthouse. The cost may be thus subdivided:—

Establishment at Hynish	£4822
Rock barrack, No. 1	790
" No. 2	1479
Establishment and quarries at North Bay ..	1883
Signal tower and lights at Hynish ..	1215
Wharf and railway at Skerryvore ..	257
Steamer, tender, and stone lighters ..	17145
Moorings	766
Boats and freight of hired vessels ..	5700
Labourers discharging cargoes	933
Travelling expenses	1711
Coals	1463
Gunpowder	375
Excavating platform	763
Dressing lighthouse blocks	9929
Tools and machinery	4267
Cartage	1104
Mortar	889
Lighthouse tower, putting together and fittings	8551
Lightroom	3851
Salaries	3656
Lightkeepers' houses	3915
Pier at Hynish	2591
Dock at Hynish for the tender	7055

From the whole cost, 2,839*l*. is to be taken off for the steamer and materials sold, but each item is given by Mr. Stevenson in detail.

Having thus followed Mr. Stevenson throughout his labours on the tower at Skerryvore, we must keep until next month our remarks on a subject no less interesting—that of lights, to which a great part of his book is devoted.

Electric Telegraphs. London: Bogue, 1848.

This is a shilling volume of scraps for the railway carriage, which contains more information about the Electric Telegraph, and more amusement, than any which has yet been published. There is not an invention in England, the United States, or abroad, which has escaped the author's attention.

Report on the Supply of Surplus Water to Manchester, Salford, and Stockport, with some Remarks upon the Construction of Rain Gauges, and the Annual Depth of Rain falling in different localities around Manchester. By S. C. Homersham, C.E. London: Weale, 1848.

This work relates to the great Manchester water controversy, which for the last few years has so much occupied that town. There are three candidates for the supply of Manchester with water: the Manchester and Salford Waterworks Company, the Corporation of Manchester, and the Manchester, Sheffield, and Lincoln Railway Company. Mr. Homersham is the follower of the last-named, and his work is therefore one-sided so far, though we believe it to be for the most part fair and straightforward.

The Waterworks Company suffer from a short supply and the bad quality of their water, which is got partly from peat-moss, and partly from the drainage of an inhabited district, but eked out by a supply from the Railway Company. The supply is clearly neither enough nor good enough for the growing town of Manchester. The town council have therefore got a bill to enable them to get water from Longdendale, gathered into reservoirs from a mossy surface. In the meanwhile they have likewise bought water of the Railway Company.

The Manchester, Sheffield, and Lincoln Railway Company having bought the Peak Forest Canal, were struck with the profit to be got by the sale of water to the great towns of Manchester and Stockport. Their canal, beginning in the Peak district of Derbyshire, among the steep hills, gives them a right to all the water not required by the millowners; and as there is much more than is wanted for the trade of the canal, it is a clear gain to sell it in those towns. The Company do not however wish to retail water to the householders, but to sell it wholesale and in bulk to the corporations or water companies. The Manchester and Salford Waterworks Company in July 1844, bought some of this water, and soon after contracted for 120,000,000 gallons yearly, for three years certain, at 2*d.* per 1,000 gallons, or a rental of 1,000*l.* yearly. In 1844, they agreed to take 50,000,000 gallons more. In August 1847, the Corporation of Manchester took for three years 200,000,000 gallons yearly, at 3*d.* per 1,000 gallons, or a rental of 2,500*l.* yearly. The Railway Company offer to supply the Corporation with seven millions of gallons of filtered water daily, at 1½*d.* per 1,000 gallons, or at a yearly rental of 15,968*l.* 15*s.*

By the enterprise of the Railway Company, this large supply of good water is secured; and we have no doubt that in many other cases, railway companies might have done great good to the public in the supply of water and gas, if it were not for the prejudices indulged in by the legislature, which shackle railway companies as they do private enterprise generally. Indeed, the whole drift of legislation is to thwart enterprise, even when there is the pretence of consulting the public interests. Thus, what with the Sanitary measure, threatening to interfere with the companies, and what with the Standing Orders, there is hardly a bill before the House of Commons for waterworks. The Board of Trade inspection presses likewise very heavily on small companies, besides the House of Commons fees.

Mr. Homersham thus describes the country around Manchester from which the water is drained for its supply:—

> "The town of Manchester is situated at an average height of about 120 feet above the mean level of the sea at Liverpool, and is bordered on the north-west, the north, the east, and the south, by high hills and upland that, in a distance varying from twelve to eighteen miles from the town, rise 1,100 to 1,900 feet above the sea, when they begin to fall in a contrary direction. The highest points in this range of hills are Rivington Pike to the north-west of Manchester, 1,545 feet above the mean level of the sea; Blackstone Edge to the north-east, about 1,450 feet; Holme Moss to the east, about 1,859 feet; Kinder Scout to the south-east. about 1,981 feet; Axe Edge, south-east by south, 1,751 feet; and Bosley Minns, nearly direct south, about 1,260 feet. These hills rise very abruptly, and the numerous valleys and mountain gorges that intersect them in various directions contain channels, called rivers or streams, that drain off the rain which falls upon them. The names of the principal rivers deriving their waters from the sources now pointed out, are the Irwell, the Irk, the Medlock, the Tame, the Etherow, the Goyt, the Dane, and the Bollin. The waters of the whole of these rivers unite in the river Mersey, and by this channel are discharged into the sea at Liverpool.
>
> The rivers upon which the towns of Manchester and Salford are situated, are the Irwell, the Irk, and the Medlock; the two latter streams joining the Irwell within the town. The area of land upon which the rain falls that feeds these streams before entering Machester is about 163,000 statute acres; of which about 11,300 drain into the river Medlock; 17,000 into the Irk; and 134,700 into the Irwell; these rivers, like all others having a similar origin, are very irregular as regards the quantity of water which passes down them at different seasons."

Nothing is idle in that busy district—even the water is made to work hard. Mr. Homersham says of the river-gods of Lancashire and Cheshire—

> "They are made to turn innumerable water-wheels, that give motion to machinery of various kinds; they are used to supply both the means of forming and condensing steam, that, properly directed, performs such a prodigy of labour with unceasing and untiring effect; they are used to scour, bleach, and dye the goods they have helped to spin and weave; and their flood-waters, collected in reservoirs, feed with water the canals and rivers that transport both the raw and manufactured material. They supply our houses with water for domestic purposes, and they perform the office of scavenger; removing from our dwellings the excretion and filth, that, remaining near us, would undermine our health, engender fevers, and cause premature death."

Of the fall of water two very interesting tables are given, which show that the depth of rain falling at the same place is very unequal in different years, and that it seems to follow no law, but the greatest depth of water falls to the west, which is nearest to the sea:—

Table.—*Showing the Depth of Rain fallen per annum for a series of years in different places situated in the upland to the west, north-east, and south of Manchester, and the level above the mean level of the sea.*

	Sharples, near Bolton.	Bolton.	Bury.	Rochdale.	Blackstone Edge.	Fairfield.	Marple.	Comb's Reservoir.	Chapel-en-le-Frith.
Level..	850 feet.	320 feet.	300 feet.	500 ft.	1500 ft.	220 ft.	531 feet.	720 feet.	1121 ft.
Year.	Inches.	Inches.	Inches.	Inch.	Inches.	Inch.	Inches.	Inches.	Inches.
1832		53·77	37·96	43·32	31·63				
1833		51·70	50·61	56·73	47·37				
1834		43·98	42·48	42·41	39·94				
1835		46·44	43·94	47·97	36·43				
1836		53·78	49·57	61·11	41·25				
1837		42·25	44·05	45·30	38·17				
1838		47·85	43·28	45·42	35·55				
1839		45·26	40·70	45·76	35·79				
1840		45·03	38·83	44·00	36·90				48·48
1841		53·87	47·37	48·55	33·50				52·30
1842		38·63	34·49	37·08	30·70				41·40
1843	63·4	49·40	40·47	50·59	36·10	38·00			41·90
1844	50·0	34·63	28·65	34·41	24·80	26·35	29·40	42·70	33·00
1845	55·0	48·11		51·64	39·80	38·90	38·80	51·10	43·80
1846	49·8	40·82		42·04	37·10	30·20	32·35	38·10	38·80
1847	61·4	52·32		51·72	35·70	40·75	43·70	51·30	44·00
Means	50·92	46·74	41·72	46·75	36·29	34·84	36·56	45·80	42·98
Lowest	49·8	34·63	28·65	34·41	24·80	26·35	29·40	38·10	33·00

Table,—*Showing the Depth of Rain fallen during the past year of* 1847, *at various places situated in the upland, east and south of Manchester, and level above the mean level of the sea.*

1847	Newton Station.	Wood-head Tunnel.	Comb's Reservoir.	Comb's Ridge.	Todd Brook Reservoir.	Brinks.
Level..	350 feet.	1,000 ft.	720 feet.	1,670 ft.	620 feet.	1,500 ft.
	Inches. 34·69	Inches. 33·12	Inches. 51·30	Inches. 35·85	Inches. 38·39	Inches. 29·50

Note.—The observations for Belmont were procured from J. Magnall, Esq.; and for Bolton from H. H. Watson, Esq.; from Bury, from J. Norris, Esq., F.R.A.S., who, since September, 1845, has removed to Howick House, near Preston; from Rochdale, from J. Ecroyd, Esq.; from Blackstone Edge, from Mr. R. Matthews, the engineer of the Rochdale Canal; and the rest from observations supplied by J. Meadows, Esq. The whole of the observations, with the single exception of Blackstone Edge, were made with rain gauges, fixed very near the ground.

Mr. Homersham charges against the corporation water that it is drained from peat land, and is charged with organic matter, which is hurtful to health. He affirms that no filtration can remedy this, as when the water is warm the peat is soluble in it.

Our author, not content with charging his opponents on every side, asserts that his own company is free from all defects, that the water is most abundant, is collected at the best time, and is little tainted by peat, while he contends that it is likewise the cheapest supply that the corporation can obtain. In his zeal, he says of the freshets impounded by the Railway Company—

> "This system of collecting water is very favourable to its *purity*, as when it flows off the hill-sides during heavy rains (except in a peaty or boggy district) it is much less contaminated than water (percolating slowly from the soil, and reduced in quantity by evaporation) which forms the streams in dry weather; besides, over most large tracts of land, consisting of thousands of acres, there will be found farm-houses and a considerable resident population, and all the excretion and filth created from these sources, with the soluble parts of manures placed on the land, must, of necessity, *drain into the streams*, and tend to foul them in comparatively dry weather, although, in heavy rains and floods, the water is not perceptibly soiled from these impurities."

We must say this doctrine is new to us, for we always considered that the freshets should, if the water could be spared, be prevented from entering the reservoirs.

Under their act of parliament the corporation are to take all the water of Longdendale into their reservoirs, and supply a daily quantity to the millowners. This, Mr. Homersham affirms, will cause a greater expense for reservoirs, and will yield less water to the corporation; and he contrasts it with the system adopted on the Peak Forest Canal, where all the water above a certain gauge goes into the canal reservoirs.

When he says that reservoirs for the millowners have not answered (p. 44), and that therefore money is not laid out by the millowners in that way, leaving the inference that the corporation reservoirs will be found expensive and useless, we think he strains his case too much, for there are many difficulties in the case of millowners, as that of getting all the millowners and landowners on the stream to join, and the great expense of getting an act of parliament.

We must notice that there is a great deal of valuable matter incidental to the discussion of the several schemes, which may be usefully read by the engineer feeling an interest in this important branch of practice. Thus, Mr. Homersham discusses rain-gauges, the fall of rain, the duration of fall, evaporation, absorption, and filtration. We should like to see complete records of the movement of some considerable streams. Mr. Homersham says below that he has made such, and we wish he had published them.

"The quantity of water flowing down streams fed from rain falling on the sides of hills varies with every passing shower; *no one or two observations per day can possibly give anything like an accurate result;* a flood will sometimes last but a few hours, and yet in this time it frequently happens more water will run down the streams than at other times will flow down in as many weeks. I have had occasion to make observations on streams every hour in fine weather, and every half hour in showery weather for weeks together, day and night, and in unsettled states of the weather almost every measurement varied."

Mr. Homersham gives an estimate of the cost of the corporation works, which at five per cent. makes a yearly cost of 20,835*l.*, while he asserts that the same quantity of water, of better quality, can be had of the Manchester, Sheffield, and Lincoln Railway Company for 15,968*l.* 15*s.* yearly, being a saving of nearly 25 per cent. All this, however, depends on what the real cost of the corporation works may be, and for that purpose we should have the estimate of their engineer, and not of Mr. Homersham. Indeed, the whole gist of the question lies upon this, which must likewise be the comment on his concluding statement.

"As you are aware, in the spring of last year the corporation could have made arrangements to secure for the use of the inhabitants of Manchester, eight millions of gallons of filtered water per day (as much as will be required for the domestic use of the borough for some years to come), delivered at Marple, 320 feet above the high part of the town, for 1½d. per 1,000 gallons: in August last year (after having spent a large sum of money in opposing your scheme), the corporation, in conjunction with the Waterworks Company, purchased of you, for three years certain, two hundred millions of gallons per annum of the same water *unfiltered*, to be delivered in the Gorton reservoirs, at 3d. per thousand gallons; or at *double* the price they might, by adopting a wiser course, a short time previously have secured the same water *filtered*."

EXPLOSIONS OF STEAM-BOILERS.

The Causes and Effects of Explosions in Steam-Engines Investigated; and their result from an explosive principle different from the force of elastic steam demonstrated; and conclusive evidence adduced that more than four-fifths of the weight and strength of the engine are required to sustain the explosive force: with an easy and certain means of preventing its destructive effects, and reducing in great part the enormous weight of the engine. By John Wilder, New York. 1847.

The elaborate title of this pamphlet fully explains the views and objects of the writer, who lives in the land of steam-boiler explosions, and seems to have had much experience therein. He commences by adducing a number of facts which are valuable in their way, but his inferences from them seem inconclusive, and often very fallacious. After mentioning several instances of the explosion of cylindrical boilers, in which the ends were blown off and projected to great distances, he proceeds to make calculations of the strength of the relative parts of such boilers, and concludes, that "it is impossible that a cylindrical boiler should be rent asunder endwise by the force of elastic steam, since half the force requisite thereto would burst it open laterally." The following is a specimen of the calculations on which he found this assumption:

"The diameter of the boiler which exploded at Baltimore, is stated in the *Sun* at 20 inches; the circumference, therefore, 62·82 inches, one-fourth whereof, 15·705, multiplied by 20, the diameter, gives 314·1 square inches as the area of the end of the boiler; but the whole periphery or ring resists the pressure on the ends, and its cohesive strength is the circumference, 62·82 inches. In like manner the rectangular section of the boiler, made by a plane passing through a portion of the axis one-fourth of the circumference in length, is 15·705, multiplied by 20, the diameter, is equal to 314·1 square inches, the area; and the pressure perpendicular thereto, the effect whereof is to burst open the boiler laterally, is resisted by the cohesive strength of half the circumference, 31·41, or the two portions of the ring or periphery, each 15·705 inches long: wherefore, in all cylindrical boilers, the amount of metal which resists the pressure on the ends is double the amount of metal which resists an equal lateral pressure; and it appears impossible that they should be rent asunder endwise by the force of elastic steam, which can never exceed the strength of the boiler in which it is generated. The area of a circle is greatest in respect of its periphery, of any figure whatever; much less, therefore, can a boiler not cylindrical be rent asunder endwise by the force of steam. But numerous cases have occurred wherein boilers have been rent asunder endwise, which could only be effected by an almost unlimited explosive power. No trace of such power is found in the history of boilers other than those of steam-engines; nor in these has it been indicated by the safety-valve or steam-gauge, although they show, with sufficient precision, the variations in the strength of steam. Against the force of elastic steam, as generated in a boiler, a properly loaded safety-valve is a complete security, but it has not the least value as against the effects of explosive action."

The "explosive principle," to the action of which Mr. Wilder attributes most of the accidents in steam-engines, appears to be electricity, though it is not so stated distinctly. This force is, he conceives, generated principally in the valve chambers in the following manner.

"It has been proved (?) that explosions in steam-engines are the consequence of the escape of elementary caloric from its combination with water or its vapour, and result directly from the removal, in the valve chamber of engines, of the compressing force which kept up the combination; for when the steam-valve is opened, the steam which passes into the valve chamber has free space to expand and the caloric to escape, but that escape and the further opening of the valve must diminish in a degree the compressing force, and be followed by a farther escape of caloric; but its amount and consequent action must depend more or less on the temperature and expansive force of steam within the boiler. The occasional violence of its action is shown by the prodigious strength of the beams, cranks, &c., which are sometimes broken. It is apparant from all considerations, that if the valve chambers be disused, and the steam let directly through the ends of the cylinder, the smallest clearance of the piston from the end, which does not admit its touching, will be the only vacant space for expansion and escape, and this need not be an hundredth part of the space in the valve chamber, and of consequence the explosive action cannot exceed the hundredth part of its present violence."

Though Mr. Wilder considers he has "proved" his position as to the cause of explosions in steam-engines, we confess that his evidence is not sufficient to satisfy us; and his opinions are frequently formed on erroneous data. He adduces, again and again, as an illustration favourable to his theory, the explosion of a gun barrel when merely corked at the muzzle, but he does not seem fully to comprehend the cause of its exploding under such circumstances; which the explosive force of gunpowder is sufficient to account for, without the supposition that any new force is suddenly brought into action. High-pressure steam is, according to Mr. Wilder, "the most elastic, yielding, and manageable of all prime movers," and only requires to be kept close, so as to prevent the escape of the "elementary caloric," to become as inexplosive as water power. We might hence indeed infer, though probably Mr. Wilder is not prepared to go so far, that high-pressure steam is dangerous only when it escapes, and that what are usually considered safety-valves ought to be regarded as generators of explosive force.

Carbonic-Acid-Gas Engine.—Another attempt to apply carbonic acid gas as a motive power, has been brought before the notice of the Paris Academy of Sciences, by M. Jagu, C.E., who proves very satisfactorily the great power that may be readily gained by imparting a comparatively low temperature to carbonic acid gas; but the difficult problem of condensing the gas, to render it again available, seems not to have been solved. M. Jagu calculates that, by suitable apparatus placed at each station, six atmospheres of carbonic acid gas may be compressed for an unlimited time, from whence the receiver may be filled. To make the gas re-enter the condensing apparatus with the absorption of as little power as possible, he proposes to place a lever on each side of the engine, put in motion by eccentrics adapted to the first moving wheels; at each extremity of the lever to be placed a winch, which will move two pistons of a given diameter, so that the gas may pass in and out.

APPARATUS FOR SUPPLYING BOILERS WITH WATER.

Report (by Order of the American Government) on an Apparatus for Supplying the Boilers of Marine Steam-Engines with a Continuous Supply of Fresh Water. Invented by Captain John Ericsson.—[From the *Franklin Journal.*]

In acceptance of your invitation of the 17th ultimo, we, the undersigned, had the honour to meet together in the city of New York, with the view of testing and reporting upon an apparatus invented by Captain John Ericsson, for the purpose of supplying the boilers of marine steam-engines with a continuous supply of fresh water, and applied by him under your direction in the United States Revenue Steamer *Legaré*.

We have now respectfully to report, that on the 23rd ultimo we embarked in the *Legaré* at 12 M., proceeded to sea, and remained on board till the following morning. During this time the boiler was in operation 15 hours, and we had ample opportunity of examining the means employed for supplying it with water and the results produced.

By the ordinary method of condensing steam in marine navigation, boilers are supplied with the *water of condensation*, composed of the steam that is withdrawn from the boiler and the necessary quantity of salt water required for its condensation. Hence, a boiler in operation is constantly parting with steam (fresh water) and receiving salt water in exchange. The effect of this operation, uninfluenced by a correction, would be, that in a few hours a degree of saturation of the water in the boiler would be reached, that would precipitate upon the plates of the furnaces and flues, a scale of sufficient thickness to arrest the passage of the heat to the surrounding water and cause the destruction of the plates, by exposing them to a temperature destructive of their tenacity. The correction in use is the removal of the water as it approaches saturation, and is effected by *blowing*, or *pumping-off*.

In the operation of either of these methods, it is apparent that there is a loss of the heat that has been imparted to the water blown or pumped off, that neglect to open or shut the blow-off cock, or in the admission of the required supply of water, involves the duration of the boiler and may, as it frequently does, involve the lives of the passengers and the crew, and the safety of the vessel. Even when all practicable attention is given to blowing-off, salt scale will be deposited in long voyages, particularly in the middle latitudes, and accumulate to an extent that renders its removal imperatively necessary. This is at all times a difficult, and even under the most favourable circumstances, an imperfect operation, and when this deposit coats the surfaces of the flues, the consumption of fuel is increased to an extent unsuited to the economy of mercantile enterprise and to the duration of operation requisite for naval purposes.

This evil may be avoided by furnishing the boilers with a full supply of fresh water, and as the weight could not be accommodated, nor the space spared in a vessel for an instrument and its fuel for the sole purpose of distilling the quantity required, it is obvious that the steam furnished by a boiler must be returned to it, after being condensed by the radiation of its heat to cold surfaces, and not by the admixture of water. This method was *proposed* by James Watt, so early as the year 1776, and has been effected to some extent by an instrument invented by Mr. Samuel Hall, of England, and applied to the engines of many steam-vessels, in some of which, notwithstanding its imperfections, it is yet used. It has failed, however, to answer the full purposes desired and anticipated.

In the arrangement of Mr. Hall a great number of thin metal tubes, from one-half to three-fourths of an inch in diameter, were placed *vertically* in a condenser and exposed to a current of cold water from the sea and into which the steam from the cylinder was admitted, for the abstraction of its heat by the radiation of it to the water without the tubes. Now it is evident, that, by this arrangement, the condensed steam would run down the inner surface of the tubes, in its passage presenting a non-conducting lining to them, and in its collection at their bottom an obstacle to the current of the steam and a diminution of the effective radiating surface.

With this method of condensation, it will be perceived that this instrument provides alone for returning to the boiler, the water that has passed through the engine as steam. It follows, then, that all escapes of steam from the boiler or engine, or water-leaks from the boiler, pipes, &c., must be replaced by distillation, at an expense of fuel, directly as the evaporation. Further continued use of this instrument exhibited an oleaginous deposit upon the inner surface of the tubes from the use of oil and tallow in the steam cylinder and on the valve faces, which, acting as a non-conductor, materially obstructed the condensation of the steam.

The apparatus of Captain Ericsson was designed to obviate the difficulties and deficiencies developed in that of Mr. Hall, and is composed of two distinct instruments, a Condenser and an Evaporator; the first for the purpose of condensation, and the latter for a supply of fresh water to provide for any losses of steam or water from the boiler by escapes, leaks, gauge vents, &c.

The Condenser is a cylindrical vessel set at a slight inclination from a horizontal line, containing the requisite extent of radiating surface in metal tubes of *two inches* bore, with an open space at each end. By this arrangement there is free space for the current of steam to pass and for the condensed steam to run down the lower side of the tubes, without presenting a lining of water to intercept radiation or an obstruction to the course of the steam. Connected with this is a pump, by which water from the sea is drawn in and forced through the spaces between the tubes and the inner surface of the shell of the condenser. Thus, the latent heat of the steam is absorbed by contact with the tubes, and condensation is effected for the double purpose of affording a vacuum for the engine and of restoring fresh water to the boiler, for continuous evaporation and condensation, to meet the requirements of the engine.

The Evaporator, as constructed, is a parallelopipedon with a semi-cylindrical top and bottom, the lower portion of which is occupied by a number of tubes similar to those in the condenser, which communicate with a valve at each end of the steam cylinder, worked by the engine: around these tubes, and for some distance above them, water from the sea is admitted for the purpose of being evaporated, and the space above this water is open to the condenser and consequently *in vacuo.* This instrument being designed to furnish fresh water to replace that which way be lost, its operation is resorted to only as occasion may require, and is effected in the following manner: when the piston is near the termination of its stroke the valve referred to opens (above or below, as the case may be), and closes when the piston begins its return stroke; by this arrangement, steam is withdrawn from the engine that has very nearly performed its full expansive effect, and passing into the tubes of the evaporator its heat is absorbed by the water surrounding them, and as this water is *in vacuo* it readily boils at a low temperature, and its vapour being led to the tubes in the condenser, it is condensed with the steam from the cylinder and is supplied to the boiler.

Upon the experimental trial to which you were pleased to request our attention, all practicable arrangements for correct observations were entered into; and with a view to acquire full and progressive notes of the operations of the apparatus, the observations of the various points were confided to special committees, which upon the conclusion of the trial, reported full notes for furnishing the following, viz.:

The boiler was filled with fresh water from above the opening of the blow-off cock; below this, salt water had been left, from an impression of its effect being too inconsiderable to authorise its removal.

At the commencement of the operation of the engine, the water in the boiler as indicated by a saline hydrometer, when at a temperature of 150° Fahrenheit, was $\cdot\frac{63}{32}$.*

The highest temperature of the *feed water* observed was 158° Fahrenheit.
The lowest 132°, and the average 150°.
The highest *vacuum* observed was from 16 to 18 inches.
The lowest from 11 to 15, and the average was from 12 to 15 inches.
The highest *steam pressure* was 54 lb. mercurial gauge.
The lowest was 20 lb., and the average was 48·6 lb.
The highest number of *revolutions* was 47 per minute.
The lowest number was 30, and the average 42·3
The point of cutting off was at three-eighths of the stroke.
The temperature of the sea water was 57.
Duration of *operation* of the engine and boiler 14 hours and 20 minutes.
Time during which steam was raised, 20 hours.

Dimensions of Engine, &c.

Cylinder.—36 inches in diameter, with a stroke of piston of 32 inches.
Boiler.—1,400 square feet of heating surface.
Condenser.—637 square feet of radiating surface.
Evaporator.—100 square feet of heating surface.

Upon coming-to, the freshness of the water was again tested, and when at a temperature of 150° by a different thermometer than that used at the first operation (it having been broken in the interim), the hydrometer indicated $\cdot\frac{76}{32}$; whether this difference in the indications is to be attributed to a change in the density of the water or to a difference in the thermometers, they being of different manufactures, we are unable to decide; fortunately the difference is quite inconsiderable, and is not regarded as deserving of further consideration.

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* 12·32 being the point of saturation of water when at a temperature of 200°.

So soon as the temperature of the Condenser was reduced to a degree that rendered an examination of it practicable, one of its heads was removed in our presence, and the tubes, when examined, were entirely free from any deposit or incrustation upon their surfaces, and the opinion is entertained, that at a temperature of feed water commensurate with economy of fuel, any difficulty from the deposit of oleaginous matter in this instrument is not to be apprehended.

Regarding the particular performances of the Condenser and Evaporator, it appeared that Capt. Ericsson had relied too confidently on a general current of the cold water through the former instrument, whereas the current was quite partial, being but directly through its narrowest part, the sides of it: hence, the upper portion of it was almost inoperative—this feature was clearly developed by the application of a hand along the surface—while the effect of it was apparent in the moderate condensation indicated by an attached mercurial gauge.

Of the Evaporator, its capacity was clearly shown, in the facility with which the level of the water in the boiler could be raised through the space between two gauge-cocks, and by a resort to its operation not being necessary for more than one-tenth of the time.

Immediately after the close of this trial, measures were taken to effect a diffused operation of the cold water, and as diaphragms could not be introduced between the tubes to alter the current of the water, without incurring an impracticable delay, the expedient of causing the steam to circulate through the tubes was resorted to, and was effected by the application of diaphragms in the open space at each end of the tubes. Upon the completion of this, a further trial was had on Friday, the 1st inst., when several observations furnished the following:—

Pressure of steam,	50 pounds mercurial gauge.
Revolutions,	47 per minute.
Vacuum,	20·5 inches.
Temperature of feed water,	150° Fahrenheit.
Temperature of sea water,	62° ,,

Compared with the ordinary method of condensation, the value of the method observed is determined by an investigation and consideration of the following points, viz.: Evaporation, Pressures, Consumption of Fuel, Safety and Duration of the Boiler.

1.—Evaporation. *Ordinary Method.*

Temperature of Feed Water, 100° *Fahrenheit.*

Temperature of sensible and latent heats of steam,	1192°
Deduct temperature of feed water, ..	100°
Heat to be added, ...	1092°

New Method.

Temperature of Feed Water, 150° *Fahrenheit*,

Temperature of sensible and latent heats ..	1192°
Deduct temperature of feed water ..	150°
Heat to be added	1042°

Then $\frac{1042}{1092}=\frac{\cdot954}{1\cdot00}$ which represents a gain in the evaporating temperature in the new method of 4·56 per cent.

2.—Pressures. *Ordinary Method.*

Pressure of steam—mercurial gauge ..	50 lb.
Vacuum, 28 inches	=13·7 lb.
	63·7 lb.

Cut off at three-eighths of the stroke.

Effective pressure on the piston ..	=47 lb.

New Method.

Pressure of steam	50 lb.
Vacuum, 20·5 inches	=10 lb.
	60 lb.
Effective pressure on the piston ..	44·5 lb.

Then $\frac{47}{44\cdot5}=\frac{1\cdot05}{1\cdot00}$ which represents a loss in pressure by the new method of 5 per cent.

3.—Consumption of Fuel. *Ordinary Method.*

In the Gulf of Mexico and between the Tropics, it is necessary to blow-off, when a hydrometer constructed similar to the one already referred to indicates $\frac{2}{32}$; in the Northern and Southern Atlantic and Pacific oceans, when it indicates $\frac{2\cdot5}{32}$. Hence $\frac{2\cdot+2\cdot5}{2}=2\cdot25$ the average point for blowing-off.

As the average degree of saturation of feed water is $\frac{\cdot75}{32}$; the quantity of water blown off compared to that fed to a boiler is as ·75 to 2·25, which is in the proportion of 1 to 3.

Temperature of the water blown off at the pressure and degree of saturation given	290°
Deduct temperature of feed water ..	100°
Temperature lost by blowing off ..	190°

As the heat to be added for the purpose of evaporation is 1092° — 1092 × 3 − 1, the proportion of feed water evaporated,	=2184°
And 190 × 3 − 2 the proportion of feed water blown off	190°
The heat absorbed, is ..	2374°

Then $\frac{190}{2374}=\frac{\cdot08}{1\cdot00}$ which represents the loss of heat by blowing off in the ordinary method of 8 per cent.

Summary of Results.

Gain by Evaporation	4 56 per cent.
Ditto by Consumption of fuel	8·00 ,,
	12·56 ,,
Loss by Pressure	5 00
Total	7·56

Which is a saving in the expenditure of heat, affording a like economy in the consumption of fuel and altogether independent of the loss of heat, by the presence of scale in a boiler, when salt water is used, and from leaks incurred by the oxidizing effects of salt water.

With the *Ordinary Method*, the level of the water in a boiler is constantly varying from one or both of the following causes, viz.: the quantity of the water blown off, or the particular extent of opening of the feed-valve; while the effective operation of the feed-pump and neglect of the blow-off valve, involves the burning, or an explosion of the boiler.

With the *New Method*, these operations are set aside: thus, blowing off is unnecessary, and the supply to the boiler being first obtained from it, the transit being immediate and the communication incapable of restriction (for if the condensed water was not taken off by the feed pump, the condenser would choke and become inoperative), there can be no decrease in the level of the water, other than that arising from leaks of water and steam. Further, the use of fresh water in a boiler will extend the term of its duration from three and five years to seven and nine.

With a further modification of the condenser, establishing a more diffused current of the cold water, it is evident that a full vacuum may be obtained, as the practicability of attaining this end by external condensation has long since been developed, and with a less proportion of radiating surface than is exposed in the instrument referred to. From the analysis however here given regarding pressures and temperatures, it would appear that a full vacuum, with corresponding reduction of the temperature of the feed water is not authorised; and as such departure from the hitherto practice, furnishes the temperature necessary to prevent any oleaginous deposit upon the surface of the tubes of the condenser, practice and utility are in desired harmony.

A very effective and economical element in steam navigation arises with the operation of this new method, from the absence of scale in the boiler, the presence of which is unavoidable where salt water is used, and to avoid the formation of it as far as practicable, other than a low temperature and corresponding pressure are precluded by the waste of fuel and injury to the boiler consequent upon the existence of this scale, acting as a new conductor of the heat to the water—whereas, with the use of fresh water, higher pressures can be worked and economy of fuel attained in an increased expansion of the steam.

Reviewing the facts herein presented, we are of the opinion that the operation of the apparatus of Captain Ericsson, as far as developed, was eminently successful, and that, with the modification of the condenser suggested, a higher degree of vacuum can be readily obtained. In view of the very great importance of the successful introduction of this method of condensation in the merchant and naval services, we recommend to your consideration the propriety of sending the *Legaré* on a distant cruise, for the purpose of developing the advantages of the apparatus by continued and extended use.

Charles H. Haswell,
Engineer-in-Chief, U. S. N.
&c. &c. &c.

New York, Oct. 31, 1847.

DECOMPOSING POWER OF WATER.

On the Decomposing Power of Water at High Temperatures. By RICHARD TILGHMAN. (Read before the American Philosophical Society, Philadelphia. [*From the Franklin Journal.*]

It has long been noticed, that partial decomposition is often effected in attempting to render anhydrous, by heat, certain salts which require a comparatively high temperature for the expulsion of their watery crystallization. This effect is not limited to those salts which are capable of decomposition by the action of heat alone, but extends to many which, when previously rendered anhydrous, are entirely unaffected by this agent. The chloride of magnesium offers a striking instance of such an action, being almost entirely reduced to magnesia, with escape of hydrochloric acid, when its solution is evaporated by a strong heat; the anhydrous chloride, when obtained by other processes, is, on the contrary, unaffected by the highest heat.

Even chloride of calcium, a salt of much stronger radical base, has been observed to give off a portion of acid, when all its water of crystallization is driven off by a red heat. In these and many other instances, it seems evident that the escaping water of the salt is the actual decomposing agent, and that the intensity of its action depends solely upon the degree of heat which the salt can sustain before giving it off.

Contact of the salt and water, at high temperatures, appears to be the only requisite of decomposition. It was therefore thought probable, that by exposing the salt, even in its anhydrous state, to a high heat, and passing over it a current of aqueous vapour, raised to a similar temperature, not only might the above-mentioned salts be completely decomposed, but also that many others which have hitherto given no such signs of partial decomposition, might be acted upon in a similar manner.

On making the experiment, it was found, that not only the anhydrous chloride of calcium, but also the chlorides of strontium and barium could be rapidly decomposed by exposing them, at a high red heat, to a current of steam; hydrochloric acid was copiously evolved, and escaped along with the excess of steam, while the bases of the respective salts were left in a free state; the lime remaining anhydrous from the intensity of the heat employed, while the baryta and strontia combined with a portion of aqueous vapour, and were found in a state of hydrates.

In these haloid salts, it is to be observed, that the addition of the elements of water is absolutely essential to the decomposition; as neither the hydrogen which is contained in the acid, nor the oxygen in the base, existed in the anhydrous salt. The action is, therefore, the result of a double decomposition between the steam and the chloride, as well as of the affinity of the liberated acid and base for water.

The oxysalts, and the sulphates of magnesia, lime, strontia, and baryta, unlike the haloid salts just mentioned, contain, even in the anhydrous state, all the elements generally considered necessary for the separate existence of the acid and bases of which they are composed. The application of the strongest heats to these salts, causes, however, no liberation of their acid; but, as with the chlorides, this effect is immediately produced by the passage of a current of steam over them at a high temperature, the baryta and strontia being left in the state of hydrates, and the other bases anhydrous.

The intensity of the affinity between the acid and base of the respective salts, is curiously illustrated by the gradual increase of the heat necessary for their decomposition by the aqueous vapour. Thus the sulphate of magnesia gives off its acid to the current of steam at a low red heat, and consequently a large portion of the acid may be condensed in an undecomposed state The sulphate of lime requires a high red heat for its decomposition, and on this account the greater part of its acid is resolved into sulphureous acid and oxygen gas. The decomposition of the sulphates of strontia and baryta, requires progressively higher heats, which, in the case of the last salt, must be raised even to low whiteness.

The subphosphate of lime, as it contains an acid much less volatile than sulphuric, combined with an excess of a powerful base, which adds to its stability, was selected as one of the most difficult tests of this decomposing power of aqueous vapour: by a full white heat, however, its phosphoric acid was slowly disengaged. This phosphoric acid gave a white precipitate with nitrate of silver, showing that its liberation and subsequent condensation in contact with a great excess of aqueous vapour, had not prevented that change which heat is known to produce upon this acid.

It might be expected from the decomposition of the salts of baryta, that the sulphates and muriates of potash and soda would undergo the same change with even greater facility. But it was found by experiment, that although the decomposition of these last salts commenced with facility, when they were exposed to steam at a red heat, yet the proportion of alkali thus liberated, never exceeded a very small per centage of the residual salt, however long the operation might be contained. Attributing this peculiarity to the volatile nature of the liberated hydrates of potash and soda at high temperatures, substances capable of forming non-volatile combinations with the alkalies were mixed with their salts, previously to subjecting them to the action of the steam; the acids were then found to be completely disengaged with facility. The fact that both lime and magnesia, substances capable of forming chemical combinations of but the most feeble character with potash and soda, were found to produce the above effect, was considered as confirming, in a great measure, the hypothesis that the volatility of their hydrates was the cause of the apparent dfficulty of completely decomposing the salts of these alkalies.

The subphosphates and subsilicates of lime, baryta, and strontia, act in the same manner as lime and magnesia, and in all these cases the chemical combination is so feeble that, when cold, the alkali is disengaged by the solvent powers of water alone.

Alumina, which possesses so much of the acid character with respect to the strong bases, is proportionably more efficient than any of the preceding substances in aiding the decomposition of the alkaline salts: it remains in combination with the alkali, when cold, as a soluble aluminate; but is easily precipitated from its solution by a current of carbonic acid gas.

The calcination of potash alum leaves a mixture of alumina and sulphate of potash, which Berthier has long since stated to be converted into aluminate of potash by the continued action of heat alone, the sulphuric acid being expelled from the potash by the superior affinity of the alumina at a high temperature. By several careful repetitions of his experiment, in which the accidental presence of aqueous vapours was entirely prevented, no decomposition of this kind could be effected, even at a white heat. But by the contact of aqueous vapour, produced by the combustion of the fuel or otherwise, even in small quantity, and at much lower temperatures, the decomposition is rapidly produced. It therefore seems probable that the accidental contact of aqueous vapour was the actual but unnoticed cause of the decomposition in Berthier's experiment.

The powerful action of aqueous vapour upon anhydrous alum at a high temperature, suggested the possibility that a similar action might take place upon its mineral representative, the double silicate of alumina and potash, or common felspar. It will be remembered that this salt, by the simple substitution of sulphuric for the silicic acid which it contains, would be converted into anhydrous alum. To the action of heat alone, felspar presents this difference from alum, that the silicate of alumina is as unaffected by it as the silicate of potash itself; so that to produce an effect upon felspar analogous to that upon alum, the silicic acid of both the silicate of alumina and of the silicate of potash would have to be removed. Silicic acid, in a *free* state, having been long known to be slightly volatile in aqueous vapour at high temperatures, it was thought that, in the present case, it might, like the other acids, be disengaged even from a state of chemical combination, by the same agents. Steam was therefore passed slowly, for some time, over small fragments of highly-heated felspar. Beyond partial fusion, no other visible change than a considerable degree of vesicularity in the parts most exposed was produced. These fragments, being finely pulverised and boiled in water, the concentrated solution was strongly alkaline, and proved, by the usual tests, to consist of aluminate of potash.

After water ceases to extract aluminate of potash from the powdered mineral, dilute sulphuric acid will produce from the residue a small portion of alum. The actual analogy between alum and felspar, substances so distinct in their origin and general properties, yet differing only in the nature of their respective acids, is rendered still more striking by both thus yielding the same product, when deprived of their acids by the same agent. It is worthy of remark, that, although the actual contact of the steam in this experiment is confined to the mere surface of the small fragments of felspar, yet the chemical decomposition produced by it is not confined to that surface, but spreads by a "cementation action," through their entire mass: pulverization is, therefore, required to obtain evidence of the internal change which has been produced.

All the experiments, so far made, would indicate that the following was the general rule applicable to all salts capable of sustaining heat alone without decomposition:—

Whenever a salt, from its own elements alone, or by the addition of those of water, can produce a volatile acid and a fixed base, the evolution of this acid and the liberation of this base will be determined by passing a current of aqueous vapour over the salt raised to a high temperature. When either the acid or base to be liberated forms a combination with water which can resist decomposition by the heat employed, the tendency to form such hydrates adds much to the decomposing power of the aqueous vapour. Although potash and soda are not by themselves fixed bases at high temperatures, yet by the use of the substances before mentioned, they can form combinations which are fixed, and by this means their salts come under the above rule.

The actual number of salts which have as yet been subjected to this mode of decomposition, is not very large; yet, from their perfect analogy of composition with many others, there can be but little doubt of the general extension of the principle.

The chlorides of potassium, sodium, barium, strontium, and calcium, being all thus decomposed, the bromides, iodides, and fluorides of the same and all weaker bases, must probably act in the same manner. The fluoride of calcium, has, in fact, been found to do so, by experiment, hydrofluoric acid being freely evolved. In the same manner, from the decomposition of the sulphates, may be inferred that of the seleniates; from the silicates, that of the borates.

The applicability of this simple mode of decomposition to the explanation of a great variety of geological changes, is too evident to escape the attention of those conversant with that science. In a future paper I hope to be able to give a more complete account of some interesting facts which have been observed in connection with this subject, and to verify, by experiment, many points which must at present be left to inference and conjecture. In fact, although the existence of this law of decomposition was ascertained in 1842, yet it has only been within a few months that I have been able to give much attention to its investigation, which must be my excuse for the imperfect and hurried manner in which it is now communicated.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF MECHANICAL ENGINEERS.

April 26.—At the quarterly meeting which took place in the theatre of the Philosophical Institution, Birmingham, George Stephenson, Esq., President, in the Chair, the following papers were read:—

CYLINDER-BORING MACHINE.

"*On the Fitting-up of Cylinders for Locomotive Engines, and a description of a Machine for Boring them.*" By Mr. C. Beyer.

In the absence of Mr. Beyer, Mr. Fothergill described the machine introduced at the last meeting, but the consideration of which was not then entered upon. [See *Journal*, p. 88.] Its object is to attain a uniformity in the make, bore, and general size of cylinders, so that, in the event of an accident, they may be replaced by spare ones. To accomplish this difficult task, the machine now described was invented. The description of this machine, which would require diagrams to make it intelligible, is briefly this:—The bed upon which it is placed is that of a common slide-lathe, sufficiently long to carry a double set of driving-gear, and admitting of the sufficient traverse of the boring-carriage. The boring-bar is supported by three bearings, the former of which is stationary, and firmly fixed to the bed, to resist the end pressure of the cut when boring; the latter are fixed upon the carriage, and travel with it along the boring-bar. To cause the boring-carriage to move edgeways, a train of wheels descend at the back of the machine to give motion to the shaft, and are transfixed by means of a feathered worm, to the worm-wheel and pinion, both of which move loose upon a fast stud of the carriage; this same stud serving as a fulcrum for a lever, carrying, upon two opposite projections, the intermediate pinions. To hold the cylinders while boring, the top of the carriage is formed into a kind of square panel, by means of two plates, planed on the inside, and fastened to the sides of the bearings, and two cross-stretches. These latter are also planed upon their inner faces, and are secured to the sides and top of the boring-carriage, and have holes bored in them when secured in their places, by means of the bend on the bar, corresponding in diameter to the turned projecting ends of the cylinder to be bored. This arrangement is for the purpose of securing uniformity between the external and internal surface, so that the cylinder be fairly perforated, without the dangerous fault of thick and thin sides.

Mr. Fothergill proceeded to explain the diagrams which accompanied the paper, and remarked that, without offering any criticism on the machine, which appeared to him to be admirable for its purpose, he would merely direct the attention of the members to the great advantages which such an invention must confer on those by whom these cylinders were used. Say, that one of those in use split—by this machine they had the defect supplied immediately.

Mr. M'Connell also bore testimony to the advantages of a uniformity of cylinder. An accident occured to one of the cylinders in use on the line with which he was connected. An order was forthwith despatched to Manchester, and in three days he had another, which fitted exactly the place occupied by the first.

ON THE FORMATION OF TEETH OF DRIVERS OF PIN-WHEELS.

The Secretary read a paper, descriptive of "*A Machine for Forming the Teeth of Wheels.*" By F. Bashforth, M.A., fellow of St John's College, Cambridge.

The paper was accompanied by a model. Referring to Prof. Willis's demonstrations, that the proper form for the teeth of spur-wheels is a compound of portions of epicycloids and hypocycloids, he remarked that no self-acting machinery had been applied to give those forms of metal wheels when mounted on their axes. The principle of the invention submitted to the Institution was the well-known one, that if the pins be supposed to be mathematical lines, the proper forms of the teeth of the driver will be portions of the epicycloids, described by a point in the circumference of the pitch circle of the pin-wheel, when caused to roll on the pitch circle of the driver. The tracer being replaced by a cylindrical cutter, this, as it revolves on its axis, will form with accuracy the interval between the two teeth of the driver. By turning the wheel to be cut through the proper angle, the interval between the next two teeth will be formed, and so on till the whole be completed. He proposed that the pins should be formed in two parts; a solid cylinder surrounded by a tube of iron; and when the tooth of the driver came in contact with the outer case of the pin, it would revolve through a small angle, and thus all abrasion of the teeth of the driver would be avoided.

Mr. M'Connell was unable to see wherein the model before them differed from the plan now in use. In fact, it was nothing more than the old cog-and-drum plan. Probably the idea occured to the inventor without any knowledge of the existing machines, and, if so, he deserved commendation for his ingenuity.

Mr. Cowper could not entirely agree with Mr. M'Connell. The teeth, by this machine, were made by a given mathematical rule. That was the only self-acting machine he had seen that struck a real epicycloid.

Mr. Fothergill was unable to see anything in the machine practically different to those longer in use. If, however, the inventor was an amateur, great credit was due to him for the inventive ability he had displayed in the model before them.

CRADDOCK'S BOILER AND CONDENSER.

Mr. T. Craddock, of Birmingham, read a paper "*On his Improved Boiler and Condenser—their Suitability for Extending the Cornish Economy, and Preventing Boiler Explosions.*"

In submitting to the meeting the subject of this paper, it appears desirable to call attention to the well-established practical data, from which, by the Cornish system of generating and using steam, such economical results have been obtained. To this end, a very brief review of the various laws, or principles, immediately bearing upon the subject, seems to be essential for placing the matter in its proper light before the meeting. For this purpose, perhaps the classified mode is the preferable one.

1. We have to do with the laws by which heat is transmitted from hotter to colder bodies, and *vice versâ*. These demand in our steam-boilers and condensers an extensive surface; and, as far as other circumstances will allow of, that such surface be composed of thin metal. It is further necessary, if we would produce the greatest economy in the generation of steam, that the heat produced in the furnace be, to as great an extent as possible, absorbed by the water; this is best effected by a subdivision of the gases by a slow draught, and by completely surrounding the combustible matter in the furnace by the water in the boiler.

2. The hydrostatic laws require, in order to render high-pressure steam equally safe from explosion as low-pressure, that we diminish the sectional area of the interior surface of the boiler, upon which the pressure of the steam acts, in the same ratio as we increase its pressure. If we do this, then the rending force, tending to burst the boiler, remains the same at whatever pressure the steam be generated.

3. The laws relating to latent and sensible heat, when considered in combination with large volumes of water, and subjected to the casualties attending the steam-engine, suggests the diminishing the quantity of water necessary in steam-boilers, as far as practical circumstancs will permit, as one of the surest means of preventing destructive boiler explosions. The importance which attaches to the suggestions these laws present becomes apparent when we consider the effects in case of explosion, which such an amount of sensible heat produced, as that contained in the large volume of water necessitated in boilers of 60-horse-power, for instance, and of the usual construction, as the sensible heat contained in so large a volume of water would, supposing the pressure of the steam to diminish from 40 lb. to 20 lb. per square inch, generate a volume of steam, at 20 lb. pressure, equal to 30,000 cubic feet. Here we have a cause equivalent to the diffusive and destructive effects exhibited in common and large boiler explosions. The boiler to which this paper refers, reduces the danger from this cause nine-tenths, though the steam be generated in it at a temperature and pressure of 100 lb. per square inch. In this case we find the sensible

heat contained in the water required by such boilers, would give but 3,000 cubic feet of steam at 20 lb. pressure. The boiler under consideration is equally successful in diminishing the risk from explosion, arising from the rending strain due to the pressure of the steam—as, on a comparison with the common boiler, in which we suppose the steam at only 36 lb. pressure, the rending force in such common boiler is 5,400 lb; whilst in the tubular, even with 100 lb. pressure, the rending force amounts only to 900 lb., or but one-sixth of that given in the instance of the common boiler. The most obvious and certain conclusion to which such well-established principles lead, cannot fail to show how ill-grounded and unscientific must be the objections raised against high-pressure steam, when generated in such boilers.

4. The laws relating to the expansive action of steam plainly indicate the importance of the two leading features of the matter before the meeting—viz.: that of removing the atmosphéric pressure from the exhaust side of the piston on the one hand, and. on the other, enabling us to make use of high-pressure steam with safety; as by the removal of the atmosphere in non-condensing engines, an economy is produced by this cause alone equal to 38 per cent.; and, by increasing the pressure of the steam at the commencement, can be obtained a further increased economy upon the Cornish system, equal to 40 per cent.

[Mr. Craddock here described, by means of plans, his boiler and condenser.]

Considerable discussion ensued upon the reading of this paper; the principal objections to the conclusion said to be arrived at were those raised by Mr. M‘Connell. It was asked by him, if any trial had been made with the engine in actual work? Mr. Craddock replied, that the trial he deemed most proper to submit to the meeting was that made at the London Works (Smethwick), because it must be free from all suspicion; and that to the authenticity of the indicator figures taken off the engine when there, he had no doubt Mr. Cowper would satisfy the meeting.

Mr. Cowper said, he had taken some indicator figures off the engine, and that it was then doing 20-horse power—that is, indicator horse-power; the condenser then took 1½-horse power to work it.

Mr. M‘Connell then raised an objection, that the engine was not tested with the other engines working at the London Works.

Mr. Craddock replied, that he had always expressed a wish that it should be so tested, but the firm not intimating its assent, it was not for him (Mr. C.) to insist upon anything of the kind.

Mr. Stephenson, Mr. M‘Connell, and Mr. Buckle said, that the test of pumping water, or some such work, was the best test of power.

Mr. Craddock replied, that he was a little surprised that Mr. Buckle, the representative of an ancient and eminent firm, should object to the indicator as a fair test of the power of the engine, when it was well known that the indicator was the instrument used by them to test the power of their own engines.

It was argued by Mr. Crampton, that the only advantages the double-cylinder engine possessed over the single one was greater steadiness of motion; but this did not compensate for the loss of power, which, he considered, arose from the use of two cylinders, in the steam passing from the one piston to the other. Some time ago, he had made some elaborate experiments upon that very subject, and his conclusions then were, that the loss amounted to 14 per cent.

Mr. Craddock replied to Mr. Crampton, by admitting a loss in the expansion, which took place between the two pistons; but, in the small engine before the meeting, it was obvious that this was reduced to the smallest possible amount: he further called Mr. Crampton's attention to the great irregularity of motion that would result by carrying the expansive principle to a great extent into one cylinder. Mr. Craddock here referred to an experiment made on the previous evening with the small engine before the meeting; it was scarcely necessary for him to remind the meeting, that in so small an engine, when first started, the friction was considerable; yet it had worked up to its speed, with the steam cut off at 1-69th of the stroke.

Mr. Crampton replied, that the steam would lose all its power before expanding to such an extent.

Mr. Craddock said, if Mr. Crampton would favour him with a call at the Works, he would show him the fact experimentally. He wished further to remind the meeting that, from his own experiments, he was convinced that, by admitting high-pressure steam direct from the boiler into one cylinder, much of it was condensed by the comparatively cold metal of such cylinder; and that the water resulting therefrom, being in contact with the metal of the cylinder, did, when placed in communication with the condenser, again assume the form of steam, thereby uselessly carrying much heat from the boiler to the condenser, without producing mechanical effect. But as he had stated his views upon this subject elsewhere, and as it may appear to the meeting a somewhat abstruse subject, if not an hypothetical one, he would not trespass upon the meeting by any further remarks upon it.

Mr. M‘Connell said, that he was somewhat surprised that after the length of time which Mr. Craddock had devoted to the subject under discusion, he had not arrived at some more accurate data, and had not made up his mind as to the real capability and comparative advantages of his boiler.

Mr. Craddock replied, that although he had certainly devoted much time to the practical consideration of the subject, he had not directly deduced such accurate data as would justify him in stating definitely the comparative merits as to economy of coals in the generation of a given weight of steam; but, nevertheless, if Mr. M‘Connell would favour him with a call at the Works, he had no doubt he should be able to show him he had not been idle, but he had been driving after great points, knowing full well that on these depended the economy.

Mr. M‘Connell said, that it appeared to him that the condenser was most valuable for marine purposes.

Mr. Craddock replied, that its advantages for such purpose may be stated in a few words, as the condenser would ensure water, free from deposit, for the use of the boiler, thereby rendering tubular boilers practicable, they enabling us to generate high-pressure steam with safety; and thus, by carrying out the expansive principle, with other consequent advantages, a saving of £2,000,000 sterling per annum may be effected in our steam navy.

Mr. Jackson proposed, that in order to test the relative value of the single and double cylinder engine, and set that question at rest—at least so far as that Society was concerned—Mr. Crampton be requested to prepare a paper and diagrams on the subject, to be laid before the members at a subsequent meeting.

Mr. Craddock suggested, that a more conclusive test would be that of an engine having two cylinders, one of which could be readily thrown out of action; its being connected with the same boiler, expanding the steam to the same extent, and performing the same work—the steam and coal required, in both cases, being accurately weighed—would give the most satisfactory solution.

The request to Mr. Crampton being carried unanimously, he (Mr. Craddock) consented to comply with such request.

HYDRAULIC STARTING APPARATUS.

Mr. Fothergill read a paper, descriptive of "*A Hydraulic Apparatus, for Connecting Heavy Machinery, and Disengaging the same from the Prime Mover, without producing those Sudden Shocks which the use of Ordinary Clutches occasion.*" By Mr. Jackson.

A level pinion is supposed to be connected with the engine, or other prime mover, and gears into a bevil wheel, to which is cast a rim, which is turned internally. The wheel turns loose upon a shaft, being lined with a brass bush; the shaft, however, is provided with four projections, through each of which a hole is bored—the centre lines of these holes lying in one horizontal plane, and meeting in one common central chamber. In these holes four rams, which are respectively cast of one piece, with blocks, are fitted, the blocks being lined with copper, and turned, so as to fit the internal surface of the rim. Supposing that the machinery, which is assumed to be connected with the shaft, required to be started, hydraulic pressure is applied to the under rams, by pressing the ram which is in the shaft down upon a column of water, also contained in the shaft and the common central chamber, by means of a fly-wheel, which, with its nut and a screw, forms one piece with the ram—this ram, the nut, and screw, being guided and supported by a brass box, which is screwed into the upper end of the shaft. It is evident, that on the ram in the shaft being thus pressed down, the under rams will gradually and simultaneously press the segments against the internal surface of the rim, with a power proportionate to the force applied at the circumference of the fly-wheel, until the friction produced by such pressure shall be equal to the resistance of the machine to be set in motion. The machine will, therefore, gradually assume the velocity, which, according to the speed of the driving-shaft, it ought to have; at the same time, that any extraordinary momentary resistance, such as might be supposed to occur occasionally in rolling-mills, or other machinery of a similar nature, instead of causing the wheel to break, will have a tendency to make the rim to slip on the segment until the obstacle be removed, or overcome. In order, however, that too great a pressure may not be applied to the lower rams, the upper one and the screw are perforated with a small opening, the extremity of which is closed by a valve, acted upon by a spiral spring, encased in the brass box—so that if, at any time, the pressure exerted upon the rams should exceed that to which the spring is regulated, the water would lift the valve, and escape through it into the box, and through an opening in the lid of the latter into the atmosphere, until the balance of the pressure was again established.

Mr. M‘Connell wished to know, whether there was any other means than that supplied by the safety-valve, if he might so call it, whereby the maximum of pressure could be ascertained.

Mr. Fothergill remarked that, in fact, the machine was a self-acting regulator. A certain amount of resistance was required to make the rams work, and whenever the resistance became too great, the spring and the valve carried off the superfluous power.—It was resolved by several of the members, that the cone seemed to answer every purpose which this machine was intended for; but it was argued by Mr. Fothergill, that Mr. Jackson's machine removed the greatest objection to the use of the cone—viz., the backward pressure. By the present invention, the pressure was confined altogether to the direction in which it was wanted. Several other members expressed themselves highly pleased with the machine; and after a vote of thanks had been passed to Mr. Jackson, it was resolved to print the communication, and lithograph the diagram, for the use of the members.